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BULLETIN 621

CONTRIBUTIONS TO ECONOMIC GEOLOGY

(SHORT PAPERS AND PRELIMINARY REPORTS)

1915

PART II.—MINERAL FUELS

M. R. CAMPBELL AND DAVID WHITE
GEOLOGISTS IN CHARGE

A. C. Preston.

WASHINGTON
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1916

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CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1915.

PART II.—MINERAL FUELS.

M. R. CAMPBELL and DAVID WHITE, *Geologists in Charge.*

INTRODUCTION.

This volume is the ninth of a series that includes Bulletins 316, 341, 381, 431, 471, 531, 541, 581, and 621, "Contributions to economic geology (Part II)" for 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, and 1915, respectively. Previous to 1906 the annual "Contributions" consisted of one part only and papers on mineral fuels were included with the papers on metals and nonmetals except fuels in a single volume. These earlier volumes are Bulletins 213, 225, 260, and 285, for 1902, 1903, 1904, and 1905, respectively. Beginning with the present volume the year included in the title will be the year of publication[1] instead of the year in which the field work reported was done. This volume is therefore dated 1915, and there will be no volume entitled "Contributions to economic geology, 1914."

As the subtitle indicates, the papers included are of two classes—(1) short papers giving comparatively detailed descriptions of occurrences that have economic interest but are not of sufficient importance to warrant a more extended description; (2) preliminary reports on economic investigations the results of which are to be published later in more detailed form. These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded. Each paper has been issued as an advance chapter as soon as it was ready.

Brief abstracts of the Survey's publications of the year are given in the annual report of the Director. The complete list of Survey publications affords, by means of finding lists of subjects and of authors, further aid in ascertaining the extent of the Survey's work in economic geology.

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[1] Owing to unexpected delays it has been impossible to publish all the chapters of the present volume within the year 1915.

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Parts that may be obtained from a laboratory supply house.

Two burners, Barthel's blast lamp. (See description below.) Any gasoline torch used by plumbers and obtained from or through hardware stores may be substituted for this.

Two iron rings with fastening screws; outside diameter, 4 inches. If base for burner as shown in figure 2 is not made, then ring stand with iron base should be ordered to hold these rings. These are described in the catalogues as "Supports, iron, rectangular base and steel rod; size of base, 6 by 4 inches; length of rod, 18 inches."

One air bath or drying oven, single wall, of heavy polished copper, with openings for thermometer and ventilation, with shelf, but without iron leg support, 6 by 8 inches.

One mortar and pestle, porcelain, with lip; shallow form; diameter, 6 centimeters (2½ inches).

One brass-wire screen, 10 mesh; 5 inches in diameter, with bottom.

One thermometer, 105° C.

One balance (pocket scales; see description below).

One pair of tweezers for handling weights; furnished with balance.

One set of weights; German silver, in box with sliding cover, each weight in separate compartment; 1 milligram to 500 milligrams.

Twelve glazed crucibles with covers; Royal Berlin porcelain, size 000; or Royal Meissen porcelain, size 8.

One pair black iron crucible tongs, 9 inches long.

Three camel's-hair brushes, small.

Six iron pipe-stem triangles, pipe stem covered; length inside, 2 inches.

One iron spatula; wood handle; length of blade, 4 inches.

One dozen round tin boxes; 2½ inches in diameter, 1⅛ inches deep.

Lead foil, 3 ounces.

Ordinary Bunsen burners may be substituted for the gasoline burners when a supply of illuminating gas is available. In ordering, these may be specified on the list in place of the blast lamps: Two Bunsen burners, ordinary type, height about 5½ inches; 12 feet tubing, white, heavy wall, inside diameter one-fourth of an inch.

List of parts to be obtained from various sources.

Two iron bases for burners, as shown in Plate I, with rod support for ring. Can be made by blacksmith or machinist.

One galvanized-iron gasoline can, capacity about 1 gallon; can be made in any tin shop.

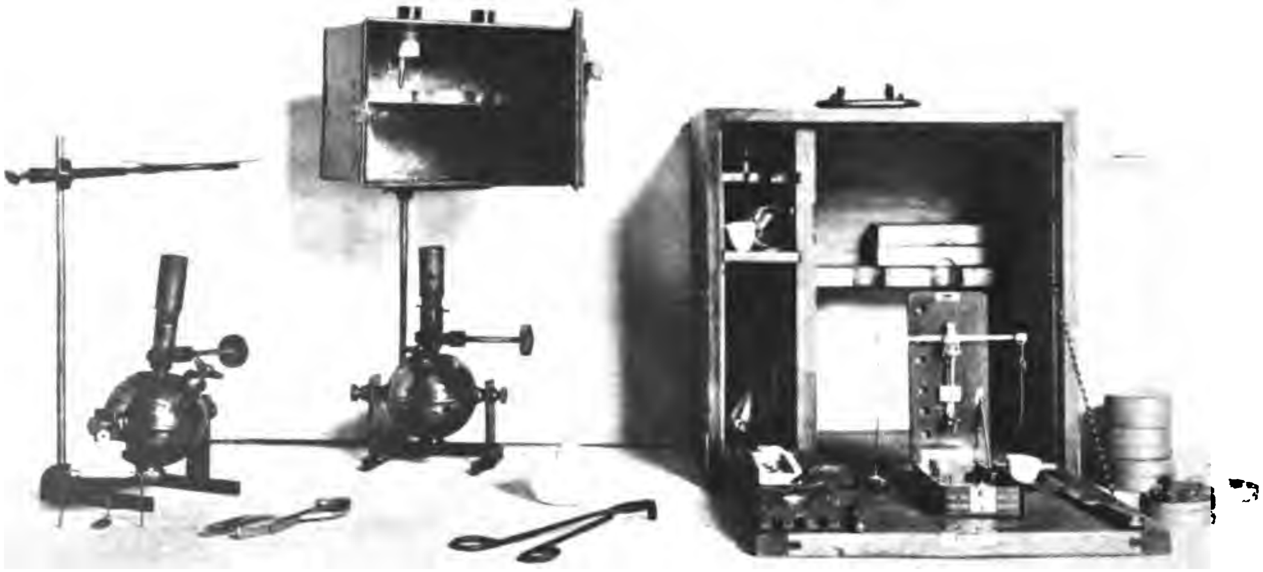
One pair nickeled combination pliers, 6½ inches long. Sold by hardware stores.

One flat file, 4 inches long.

One box with compartments for holding parts of outfit. To be made by carpenter. Necessary only for portable outfit.

Six inches of fine iron wire.

Regarding most of the articles named, no comment is necessary The legs usually provided with the air bath are not necessary, as the bath can be heated on a camp or heating stove or by one of the gasoline burners (Pl. I). The sample tins are ordinary druggist's "salve boxes," the lids of which fit tightly enough to prevent loss of moisture, and being smooth and rounded inside, furnish a convenient receptacle for the sample while it is being air-dried. Corresponding numbers are stamped on the lids and bottoms to prevent confusion in handling. The crucibles are about 1 inch in diameter



FIELD APPARATUS FOR DETERMINING ASH IN COAL.

at the top and 1 inch deep and are small enough to allow the full flame from the burner to envelop them. The crucible is provided with a lid, which should be in place at the beginning of the operation of burning and also while the crucible is cooling. The pliers are necessary in handling the gasoline burners.

The two articles calling for the most care in selection and of which there are a variety of types available are the balance and burner. The balance, selected after several others, large and small, were considered, is described in the trade catalogue as a "Pocket scale, capacity 10 grams, and sensitive to 1 milligram." This balance is of the "take down" variety and when closed measures 6 by 2½ by 1⅛ inches. It is easily sensitive to 5 milligrams and by careful manipulation can be read to 1 milligram. As furnished it has one serious disadvantage, namely, that the pans are attached to the beam by cords and can not readily be removed. To overcome this defect supports may be made consisting of a German silver wire hooked to the cross beam above and attached below to flat folding cross pieces bent to fit the pan, on which the pan may be placed and from which it can be removed at will. One of these supports is shown in figure 1. They nest into the case with the pans and contribute largely to the successful use of the balance. A set of milligram weights accompanies the balance, but they are all in one small compartment and are not readily accessible. It is best to keep these as a reserve and to add to the outfit an additional set of German silver weights (500 milligrams to 1 milligram) in a small box with sliding cover and with a compartment for each weight. A slide in the back of the balance case holds the tweezers for handling the weights.

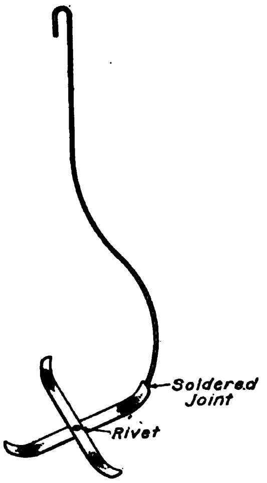


FIGURE 1.—Pan support for balance.

Gasoline was selected as a fuel because it is cleaner than kerosene and gives a hotter flame than alcohol and can be used in any type of gasoline burner. The burner adopted for the field outfit is a special type known as "Barthel's automatic blast lamp" (fig. 2), which has several decided advantages over the ordinary horizontal flame plumber's torch. It uses gasoline for fuel; it has the Meker burner, which gives better combustion and a hotter flame than other burners; it is automatic in that it requires no pumping to keep up the air pressure; and in its normal position it gives a vertical flame. This burner can be purchased without the cast-iron base and a light skeleton base (fig. 2) can be made to support both the burner and

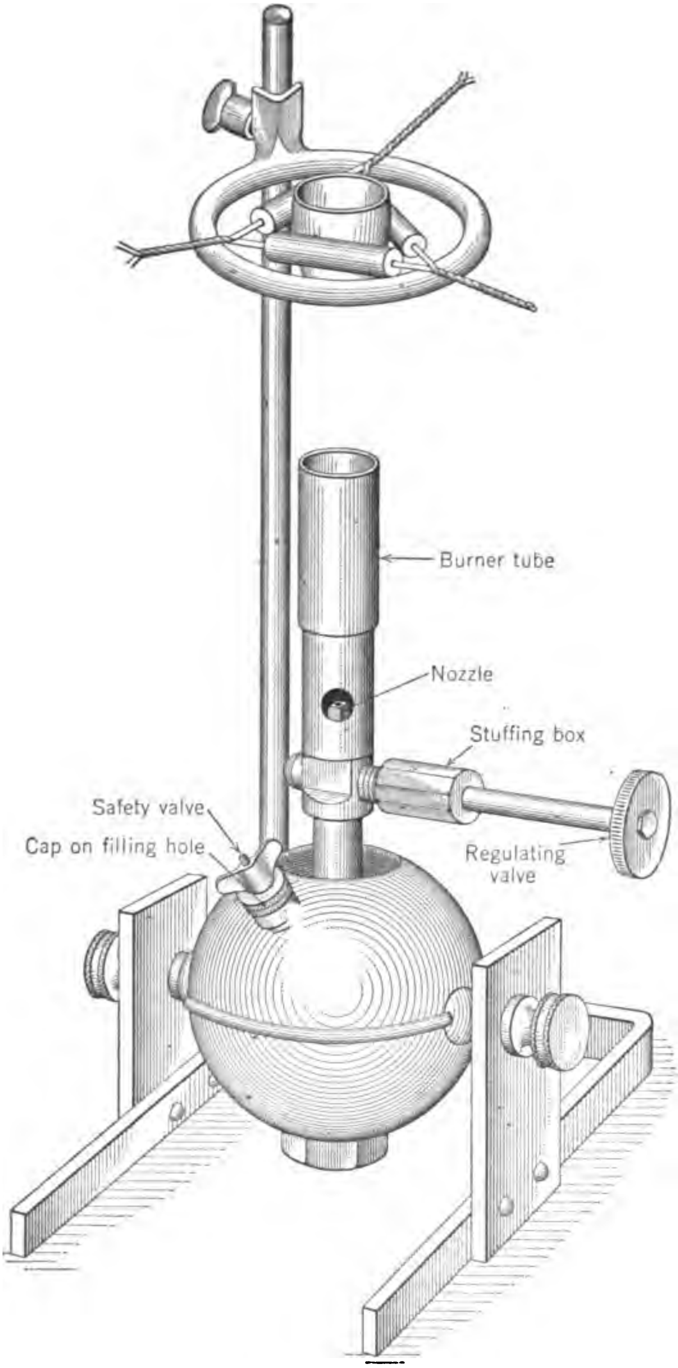


FIGURE 2.—Barthel's gasoline blast lamp.

the ring stand on which the crucible is set. This base can be easily made by any blacksmith or machinist and is inexpensive. The lamp has two burners, so that one operator can almost double the number of determinations in a given time.

OPERATION OF THE BURNER.

The following instructions for the use of the Barthel blast lamp should be carefully followed: In filling close the regulating valve (fig. 2), remove the cap to the filling hole, and fill the reservoir with gasoline to within about an inch of the top and screw the cap on tightly with the pliers.

In preparing to light set the burner upright and fill the hollow around the base of the burner tube with gasoline. A convenient way of doing this is to pour the gasoline into the top of the burner tube, through which it will flow into the hollow. Light the gasoline in the hollow and protect the flame from drafts. If an excess of gasoline is poured, overflowing the hollow, and the burner be enveloped in flame, no harm may be expected to result, for if the reservoir is overheated, the pressure, if excessive, will open the safety valve in the cap on the filling hole. When the valve is thus opened gasoline or gasoline vapor is forced out of the small hole in the side of the screw cap and, of course, will take fire. By opening wide the regulating valve and closing the safety valve by tapping on the point in the end of the cap proper conditions will be restored. Some who have used this burner advise leaving the regulating valve slightly open while the burner is heating to avoid too high a pressure. When the gasoline in the hollow is nearly all burned out open the regulating valve and light the escaping vapors at the upper end of the burner. The flame when burning properly is blue to almost colorless and can be adjusted as to height by opening or shutting the valve. To extinguish the flame close the valve tightly by turning it to the right. If when extinguished a small yellow flame appears in the lower part of the burner, it should be blown out to prevent carbon from depositing in the valve opening, and the handle should then be turned to the left about a quarter of a turn, so that when cool the needle valve will not be jammed tight. If relighted without refilling, the valve should first be opened to allow the air to enter the reservoir, then closed and heated as described above.

Should the burner not be heated sufficiently at the beginning, it will burn improperly, giving an irregular, sputtering, yellow flame. To remedy this trouble shut off the burner and heat again with gasoline in the hollow cup without waiting for the burner to cool. Irregular action may be caused by the clogging of the valve opening. To remedy this trouble unscrew the burner tube and clean the hole with the cleaning wire that is provided with the outfit. If this does not help, unscrew the nozzle of the valve (fig. 2) and replace the fine wire gauze. After it has been long used the wick in the reservoir must be replaced by unscrewing the cap on the bottom of the reservoir. If leakage around the cap over the filling hole can not be stopped by tightening the cap, a new washer should be put in. This washer should have a hole in the center to allow the safety valve to work. Likewise, if there is leakage of vapor around the spindle of the regulating valve, the stuffing box should be tightened or repacked. The reservoir may be refilled while hot without danger.

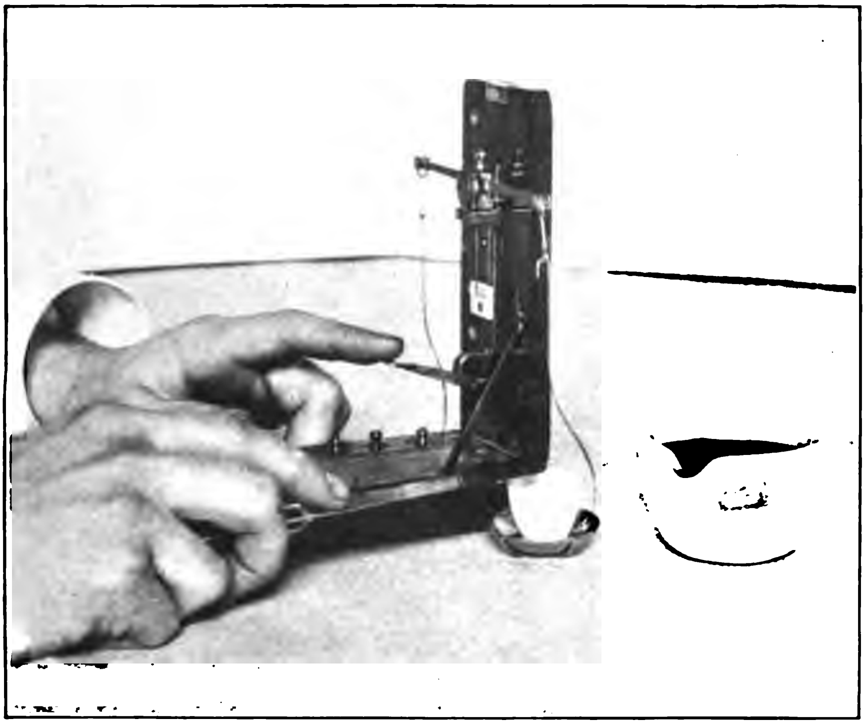
OPERATION OF THE BALANCE.

In setting up the balance for the first time try different combinations of hangers and pans to find which pans are in balance; then mark, by scratching with a pin or a knife blade, those on the right with "R" and those on the left with "L."

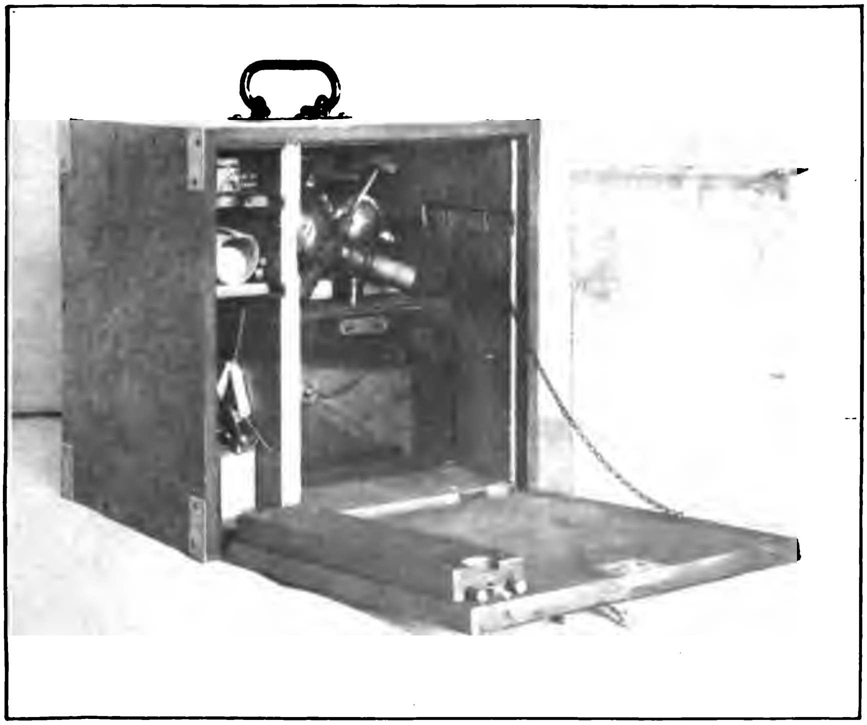
The easiest and quickest way of determining when the pans are in balance is to press (Pl. II, *A*), not too quickly, the lever which raises the beam and observe the action of the pointer. If the end of the pointer holds its position over the center of the scale, the pans are of equal weight. If it moves to one side or the other, the side to which it moves is light. If it moves quickly the difference in weight is large; if it moves very slowly, the difference is slight. As soon as the way the pointer tends to move is observed the lever should be released, weight added or removed, and the operation repeated. This method is better and quicker than that of raising the beam and allowing the pointer to oscillate back and forth till it comes to rest. It is generally more convenient to place the material to be weighed in the right pan and the weights in the left pan. When a sample of coal is to be weighed put the brass weight, together with the corresponding lead counterpoise (pp. 8–9), in the left pan and the crucible in the right pan. Add coal to the crucible in decreasing quantities as the amount approaches a gram, holding the spatula with powdered coal on its tip in the right hand and tapping it with the index finger so that small quantities of the powder may fall into the crucible, using the forefinger of the left hand for raising and lowering the balance pans (Pl. II, *A*). After each addition of coal to the crucible raise the beam and observe the action of the pointer. In weighing the ash put the crucible in the right pan and add weights to the left pan with the counterpoise to balance.

METHOD OF ANALYSIS.

The sample should first be crushed to half-inch size and then reduced by successive quartering and crushing, so that finally not more than a quarter of a pound remains, all of which will pass through the 10-mesh screen. The sample can be mixed and quartered to



A. WEIGHING A SAMPLE OF COAL FOR DETERMINATION OF ASH.



B. APPARATUS PACKED IN CARRYING CASE, WITH GASOLINE CAN REMOVED TO SHOW INTERIOR ARRANGEMENT.

advantage on a piece of heavy wrapping paper, or on oilcloth or rubber cloth. Three grams of the sample are obtained by taking small quantities on the point of the spatula from different places in the bottom pan of the screen. This sample is weighed directly on the scale pan and from there brushed with a camel's-hair brush into the lid of the sample tin and placed in the air bath for drying.

Before the coal is burned to ash it should generally be dried, for all coal contains moisture, partly as water adhering to and wetting the particles and partly as water in the coal itself. The amount of water differs in different coals, Pennsylvania anthracite containing as low as 0.6 per cent and some North Dakota lignite containing more than 40 per cent. The moisture content of specimens of coals that contain more than a small percentage of water and that have been exposed to the atmosphere varies more or less with changes in the humidity of the air and with the length of exposure, because a part of the moisture is loosely held in the coal and, if the coal is exposed in a dry atmosphere, will evaporate.

The sample should be submitted to a preliminary drying, because evaporation may take place rapidly, as, for instance, in a lignite or low-grade subbituminous coal, where loss of water occurs so quickly that the surface of a sample may be seen to crack.

The effect of varying amounts of moisture in the samples analyzed may be illustrated simply as follows: Assume a 100-pound sample of lignite to contain 30 pounds of moisture and 10 pounds of ash. Analysis will show, therefore, 10 per cent of ash. If, however, the sample is exposed to the air, water will evaporate. If 10 pounds of water evaporates, the sample will weigh 90 pounds, of which 10 pounds are ash. Analysis will now show 11.1 per cent of ash, an increase of 1.1 per cent. If the sample is analyzed after it has lost 20 pounds of moisture, it will be found to contain 12.5 per cent of ash, an increase of 2.5 per cent, and if the loss of moisture is 30 pounds, the percentage of ash will be 14.2 per cent, an increase of 4.2 per cent. In other words, two samples of the same coal will, if one is wetter than the other, show on analysis different percentages of ash. If, however, the loosely held water in both is driven off under like conditions of temperature, the percentage of ash should be the same.

The obvious method of removing such a source of apparent discrepancy is, at the beginning, to dry the coal at room temperature until all the moisture that it will give off at that temperature is removed. A sample so treated will undergo the minimum amount of change in moisture content thereafter when exposed to the air. For this reason the usual laboratory practice is to dry all samples of coal under certain fixed conditions before they are analyzed. The standard practice at the Pittsburgh laboratory of the United States Bureau of Mines is to pass a current of air at a temperature of 35° C. (95° F.)

over the coal until it shows no further appreciable loss of moisture. This process is called air-drying, and the difference in weight before and after drying is called the "air-drying loss."

In using the field apparatus it is best to dry the samples at 60° C. (140° F.) with the sample on the middle shelf, the bulb of the thermometer half an inch above the coal, and the door of the oven open about an inch. It is of course impossible by a treatment lasting but an hour to duplicate results on air-drying loss that are obtained in the laboratory under conditions carefully chosen and controlled and by drying for long periods.[1] Other things being equal, the error in percentage of air-drying loss will vary with the amount of moisture, being greatest with the highest moisture coals. It will not by this method, however, be over 3 or 4 per cent in a sample of lignite showing an air-drying loss of 30 or more per cent and as a difference of 3 per cent in a sample having 30 per cent air-drying loss makes a difference in the percentage of ash of but 0.03 per cent if the ash is 5 per cent, or 0.06 per cent if the ash is 10 per cent, it is evident that the method is sufficiently accurate for the purpose intended. After drying for 1 hour the coal is brushed into the balance pan and weighed, the loss in weight being the air-drying loss. An example showing the calculation of this in percentage will be given later.

The method ordinarily employed in laboratories for determining ash in coal is to heat a small weighed portion of the powdered sample to a red heat and to allow fresh air to come in contact with the heated coal. All water is driven off and the solid carbon and tarry compounds are burned, passing off as gases and leaving behind the mineral matter or ash, which is composed of silica, clay, iron oxides, and sulphates in various proportions. The procedure recommended with the field outfit is as follows:

The air-dry sample is quickly pulverized very fine with the mortar and pestle and 1 gram is weighed out into a crucible. It may not always be necessary or even advisable to use 1 gram of coal for burning to ash. If the ash is more than 15 per cent the time required to burn off completely 1 gram is considerably increased, and for this reason one-half gram may be used. It should be borne in mind, however, that the smaller the sample used the greater is the liability of error in the final result, and when the smaller amount is used extra care should be taken in the weighing of the sample both before and after burning. For each crucible in use a counterweight of lead foil should first be made, so that by having it on the opposite pan of the balance when the coal and the ash are weighed the actual weighing of the crucible is obviated. The counterpoise should be within 1 or 2 milligrams of the weight of the crucible, and since the latter changes weight with use it is necessary after several days' use to correct the weight of the counterpoise by addition or subtraction of lead. After the sample is weighed set the covered crucible upright in a pipestem triangle on the ring stand, adjusting the opening in the triangle by bending the wires so that about two-thirds of the crucible projects below. Adjust the regulating valve of the burner until the flame of the blast lamp is about 3 inches long, and arrange it so that the top of the flame just touches the bottom of the crucible on one side. Increase the heat gradually by turning the regulating valve to the left so that after 10 minutes the bottom of the crucible is red hot. Ordinarily by this time all moisture and tar are driven off, a portion of the tar having condensed on the upper part of the crucible and on the under side of the lid, and no fumes or smoke can be observed coming off. Lignite and subbituminous coal (black lignite), being high in moisture, are apt to sputter when first heated. By heating slowly at first, as described above, with the flame directed well up against the side of the crucible this tendency is reduced and the cover prevents loss if the sputtering is slight. At the first evidence of this tendency the heat should be reduced by turning down the flame of the burner. If, however, the sputtering takes place with sufficient violence to bounce the lid and throw out powdered coal, which will be shown by sparks appearing in the flame outside the crucible, the test is probably spoiled and should be repeated.

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[1] Mine samples of coal crushed to pass a ¼-inch screen, and spread out to a depth not exceeding 1 inch, in circulating air at a temperature of 10° C. higher than room temperature will become approximately air dry in the following periods of time: Appalachian coals, 8 to 24 hours; Illinois and similar coals, 12 to 48 hours; subbituminous coals and lignites, 48 to 72 hours (Fieldner, A. C., The sampling and analysis of coal: U. S. Bureau of Mines Tech. Paper 76 p. 52, 1914).

As soon as all moisture and tar are driven off, remove the cover, tilt the crucible to about 45° on the triangle (Pl. I), and apply the full blast, arranging it so that little or no flame is in front of the crucible to interfere with the free access of air to the coal. As burning proceeds the coal will glow and at times a small flame may be seen playing round inside the crucible. A cover of ash soon forms on top of the mass and checks the speed of burning, so that by stirring every few moments with a fine iron wire, taking care each time to tap the wire before removing it to dislodge adhering ash and coal, the operation is expedited. The crucible should be turned around as the burning proceeds until all the black coating of tar on the inside, formed in the earlier part of the operation, is burned off and the heating and stirring should be continued until the residue no longer glows but appears "dead" as contrasted with the hot pulverized coal, which when stirred appears to flow like water or quicksilver.

The burning of a 1-gram sample to ash should be completed in about 30 minutes, after which the crucible should be removed from the flame, covered, and allowed to cool. A convenient holder for the hot crucible is made by bending down the wires of a pipestem triangle (Pl. I) to form legs. When cool enough to handle, the ash may be examined to see whether it contains any unburned black particles. If completely burned it will show no such particles, and its color will be either grayish white or, if it contains much iron, pink or red. The crucible containing the ash is placed on one pan of the balance and the lead counterpoise for that crucible on the other, with sufficient weights to balance the ash. Calculations of the result in percentage will be given later.

Until the operator has had considerable experience in making tests there is always the possibility of mixing the crucibles, their counterpoises, and the sample tins, so that in the end there may be uncertainty as to what sample is represented by the test, or whether the proper counterpoise has been used. To avoid this it is advisable to mark the crucibles and counterpoises with numbers corresponding to those on the sample tins. A number may be marked on the lead with a hard pencil or written in ink, and may be written on the bottom of the crucible with a piece of red ocher (hematite); or notches may be filed on the upper edge of the crucible with the corner of a file. These notches should of course be made before the lead counterpoise is made. With experience it will be found that if the same order and arrangement is always followed, numbering will cease to be necessary and there will be no danger of confusing the samples and crucibles.

EXPLANATION OF WEIGHTS AND CALCULATION OF RESULTS.

The brass weights in the case range from 1 gram to 10 grams, and are stamped with figures representing the number of grams. The German silver weights range from 0.001 to 0.5 gram and are stamped with the number of milligrams. The equivalents of milligrams in fractions of a gram are shown below.

Number of milligrams.	Fraction of a gram.
500	0.5
200	.2
100	.1
50	.05
20	.02
10	.01
5	.005
2	.002
1	.001

That is, 1,000 milligrams equal 1 gram and 10 milligrams equal 0.01 (one one-hundredth) gram. Therefore, if the ash from 1 gram of coal weighs 10 milligrams the coal is one one-hundredth (0.01) or 1 per cent ash.

Example: Three grams of coal are taken, which after drying require 2 grams and 310 milligrams (2.31 grams) to balance. What is the air-drying loss?

	Grams.
Original weight	3.00
Weight after drying	2.31
Loss of weight	.69

As 0.69 represents the loss for 3 grams, the loss for one gram is 0.69 divided by 3; that is, 0.23 grams = 230 milligrams. Each 10 milligrams corresponds to 1 per cent; 230 ÷ 10 = 23; the air-drying loss is 23 per cent. The same result is obtained by the familiar method of calculating percentages. Three grams of sample contains 0.69 grams of moisture.

$$\frac{\text{Per cent of moisture}}{100}=\frac{0.69}{3}.\quad \text{Per cent of moisture}=\frac{100\times0.69}{3}=23$$

If 1 gram of this dried coal, after burning, leaves 120 milligrams (0.120 grams) of ash, the percentage of ash is (120 ÷ 10) 12, as each 10 milligrams of ash represents 1 per cent of the original gram. Calculated by method of percentage the result is:

$$\text{Per cent of ash}=\frac{100\times.120}{1.00}=\frac{12.00}{1.00}=12$$

Should one-half gram of coal be taken, the ash of the coal last considered will weigh 60 milligrams (0.060 grams) and as with one-half gram sample each 5 milligrams of ash corresponds to 1 per cent, the result is 60 ÷ 5, or 12 per cent ash. Calculated by percentage, the result is:

$$\text{Per cent of ash}=\frac{100\times.060}{.5}=\frac{6.0}{.5}=12$$

In order to give the reader an idea of the relative accuracy of an analysis made with the field outfit as compared with that made in the laboratory the results of tests made by the writer and others on duplicate samples analyzed by the Pittsburgh Laboratory of the Bureau of Mines are given in the following table:

Comparison of results of analyses of samples of coals by laboratory of Bureau of Mines and by Geological Survey's field apparatus.

	Kind of coal.	Bureau of Mines laboratory No.	Percentage of ash in air-dry coal.	
			Bureau of Mines.	Field outfit.
1	Lignite	[a] 14729	12	13
2	Bituminous	[b] 17707	16.2	16
3	.....do	[b] 17705	25.6	25
4	.....do	20168	17.95	17.8
5	.....do	20170	20.9	21

[a] U. S. Bureau of Mines Bull. 85, p. 60, 1914.
[b] U. S. Geol. Survey Bull. 541, p. 412, 1914.

Field analyses 1, 2, and 3 were made by the writer in camp at 30 to 40 miles from a railroad, analysis 1 in North Dakota, under adverse conditions because of high winds. Tests of the apparatus have been made by many members of the Geological Survey on coal of all grades, from Rhode Island anthracite to brown lignite.

THE HEALDTON OIL FIELD, CARTER COUNTY, OKLAHOMA.

By CARROLL H. WEGEMANN and KENNETH C. HEALD.

INTRODUCTION.

The first well in the Healdton field, the greatest oil field yet discovered in the "Red Beds" area of Oklahoma, was drilled by the Red River Oil Co. (now the Dundee Oil Co.) in August, 1913, on the farm of Wirt Franklin, in the NE. ¼ sec. 8, T. 4 S., R. 3 W. This well is on the southwest side of the pool, and probably had it been drilled a quarter of a mile farther southwest it would have missed the pool entirely. The initial production was not large, being estimated at about 25 barrels a day, but the news of the finding of oil in this area created great excitement. Crowds from Ardmore, 20 miles east of the field, and from Waurika, 25 miles west, as well as from the surrounding country, watched with keen interest the drilling of the second well by the Red River Co., half a mile northwest of No. 1, on land belonging to Mary McClure. This well came in at 300 barrels a day, and during the year after its completion the development of the field was extremely rapid. Some of the later wells were reported to have initial productions of 4,000 to 5,000 barrels a day. A branch railroad was built from Ardmore to the new towns of Wilson and Ringling, situated respectively southeast and south of the field, and a settlement of hastily constructed shacks and tents known as Ragtown grew up in the field itself.

The Magnolia Pipe Line Co. extended a branch from Bowie, Tex., to the Healdton field by way of Waurika, but the output of the field was so great that the line was unable to handle all of it, and operators placed their oil in earthen reservoirs and steel storage tanks. During a thunder storm in the summer of 1914 several of the tanks were struck by lightning and a great quantity of oil was destroyed by fire. Oil in earthen reservoirs deteriorated, losing by evaporation its gasoline and other volatile constituents, and great quantities of crude oil were lost by the washing away of the dikes which formed the reservoirs. The entire losses in the field were enormous, and the depression in the oil market in the autumn of 1914 tended to retard drilling, which has not yet (March, 1915) been actively resumed.

In October and November, 1914, a field party of the United States Geological Survey made an accurate survey of the Healdton pool, and

through the courtesy of operators the logs of practically all the w
(about 275) were obtained.

With more than the usual amount of data at hand, it has b
possible to contour in great detail the surface of one of the oil sa
of the field and thus to determine precisely the nature of the struct
on which the accumulation of the oil depends. The structure is m
more irregular than is generally conceived, and its irregularities, wh
are described in this report, probably control the distribution of
and have much to do with the variations in production of oil
adjacent wells.

LOCATION OF THE FIELD.

The Healdton field (Pl. III) lies on the west border of Carter Cou
about 25 miles north of Red River, which forms the south bou
ary of the State of Oklahoma. The field may be reached fr
Waurika, about 25 miles west and a little south of it, on the Chica
Rock Island & Pacific Railway, or from Ardmore, which lies 20 mi
to the east of the field, on the Atchison, Topeka & Santa Fe Railw
From Ardmore a branch railroad runs to Ringling, 5 miles south
the field.

About 12 miles northeast of the Healdton field is the west end
the Arbuckle Mountains, and midway between the mountains and
field is the small Wheeler oil field, opened in 1904. Some 10 mi
northwest of the Healdton field are the gas wells near Loco, the fi
of which was drilled about six months before the Healdton field
discovered. (See fig. 3.)

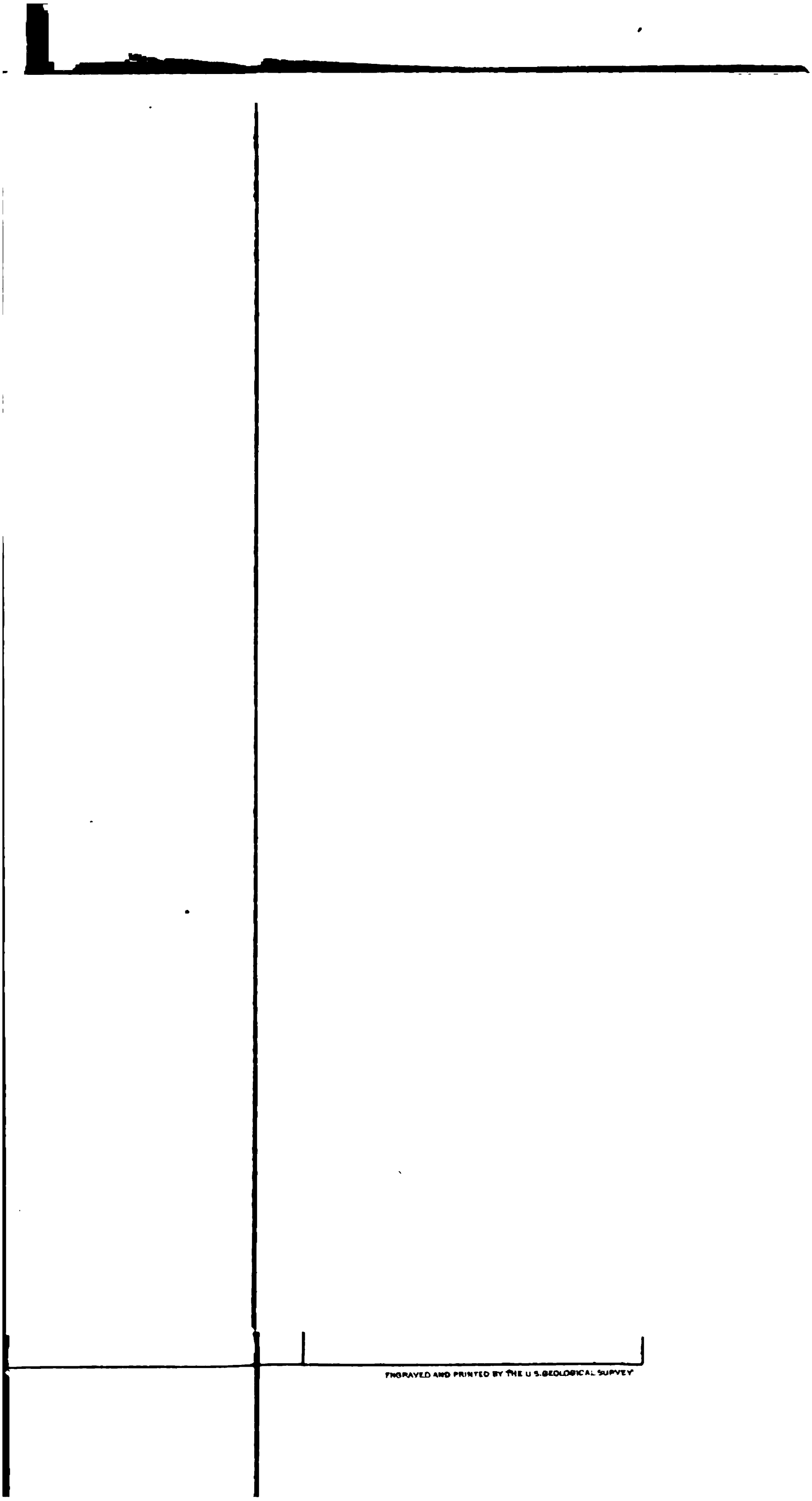
TOPOGRAPHY AND DRAINAGE.

The Healdton field is on the boundary between the belt of san
timbered country that borders the Arbuckle Mountains in this regi
and the rolling plains that lie in Oklahoma southwest of the mou
tains. The relief is not more than 150 feet over the entire field, a
rock outcrops are very few.

The area is drained by comparatively small southward-flowi
branches of Red River, which have cut their channels but lit
below the comparatively level surface of the region. The draina
net is simple.

STRATIGRAPHY.

The surface rocks in the Healdton field consist of alternating be
of red and gray shale, brown, white, and red sandstone, and thin be
of conglomerate the pebbles of which are principally quartz. Th
belong to the series of strata known as the "Red Beds" and are
Permian age. The precise nature of the conditions under which th
Permian beds were formed is not clear. To the south, in Texas, the
were put down, in part at least, in an ocean, as is shown by th



ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

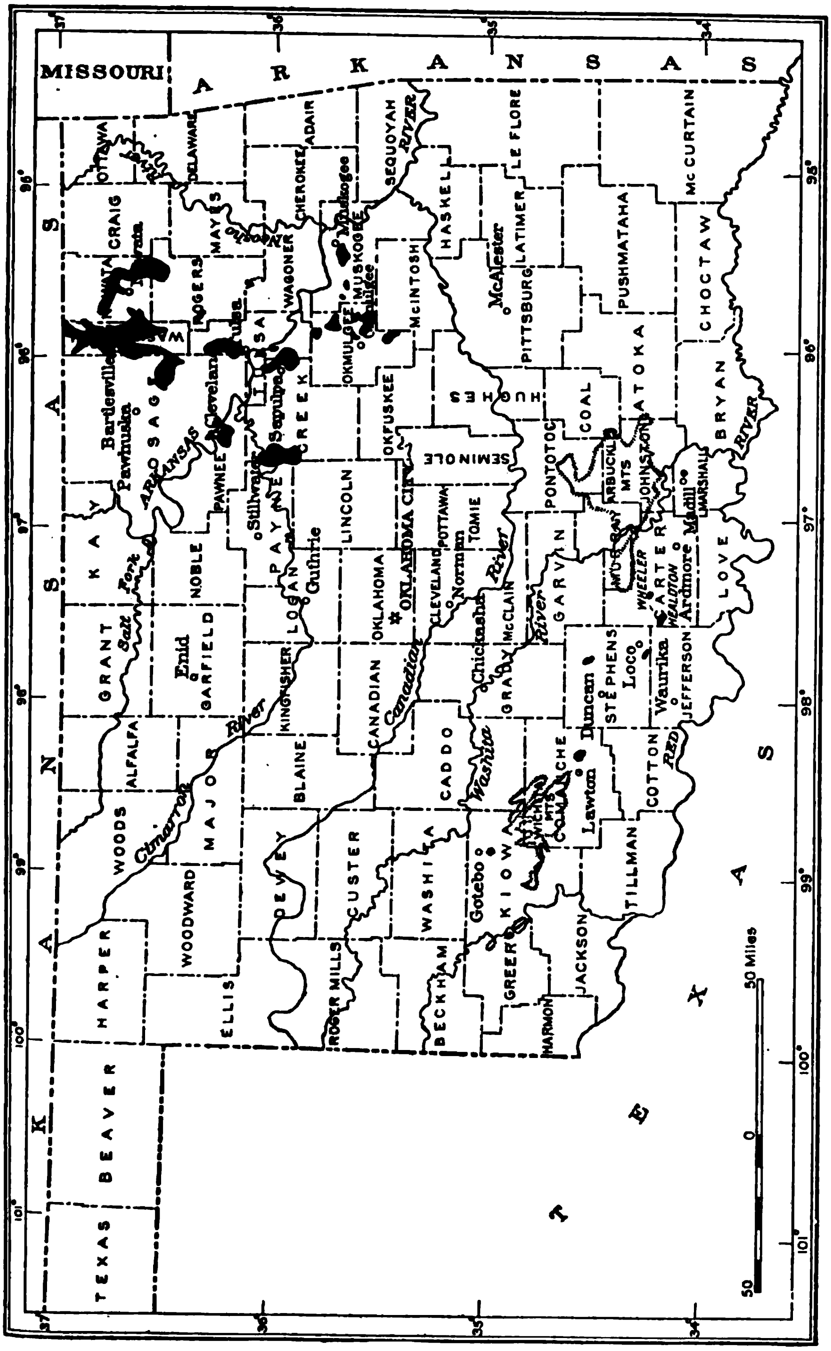


FIGURE 3.—Index map of the oil and gas fields of Oklahoma.

presence of limestones which bear marine shells; but farther north, in the area under discussion, which lay nearer to the old shore line, the conditions of sedimentation appear to have been rather fluviatile or estuarine. The beds are at least in part of fresh-water origin. The bones of animals that were probably land forms are found among them, and plant remains occur at certain localities.

Some of the sandstone beds are very irregular in thickness and are replaced laterally by shale, but others, such as the sandstone that forms the escarpment in the Duncan gas field, 20 miles north of Healdton, can be traced for 50 to 75 miles, showing that they must have been put down under conditions which allowed considerable regularity of deposition. However, although certain groups of sandy beds persist over great areas, the individual beds of sandstone that compose the groups are in themselves irregular. The broad extent of such deposits does not preclude the possibility of their deposition by rivers.

The origin of the red color of certain of the Permian beds is a question that has been much discussed. It seems probable that the red color of the beds does not necessarily imply aridity of climate during their deposition. That the beds were red when originally deposited is presumably to be conceded, although it must be admitted that in certain beds the red color has been changed to blue or bluish gray, and vice versa. At the present day red soils are formed as a rule in warm, moist climates, where vegetation is abundant and surface weathering deep, and it seems reasonable to suppose that similar conditions of climate and weathering prevailed at the time of the formation of the "Red Beds," at least in the region from which the sediments were derived. If, however, vegetation had been abundant in the waters in which the red sediments were deposited, it is probable that the carbonaceous matter would have acted as a deoxidizing agent, changing the color of the sediments with which it was mingled from red to blue. The whole problem of the deposition of the "Red Beds" is not well understood.

The red color of the Permian extends to depths of 200 to 300 feet below the surface on the Healdton dome, but, as is abundantly proved by the logs of the wells, the lower limit of the red color is by no means at a constant horizon. Shale beds which are in one well blue are in another red, and vice versa, the color changing from place to place.

How many feet of Permian beds have been removed by erosion from this area can only be surmised. In the present work the general relations of the strata at Healdton and those in the Loco, Duncan, and Lawton fields have been determined with a fair degree of certainty, and if, as stated by Taff,[1] the highest peaks of the Wichita Mountains

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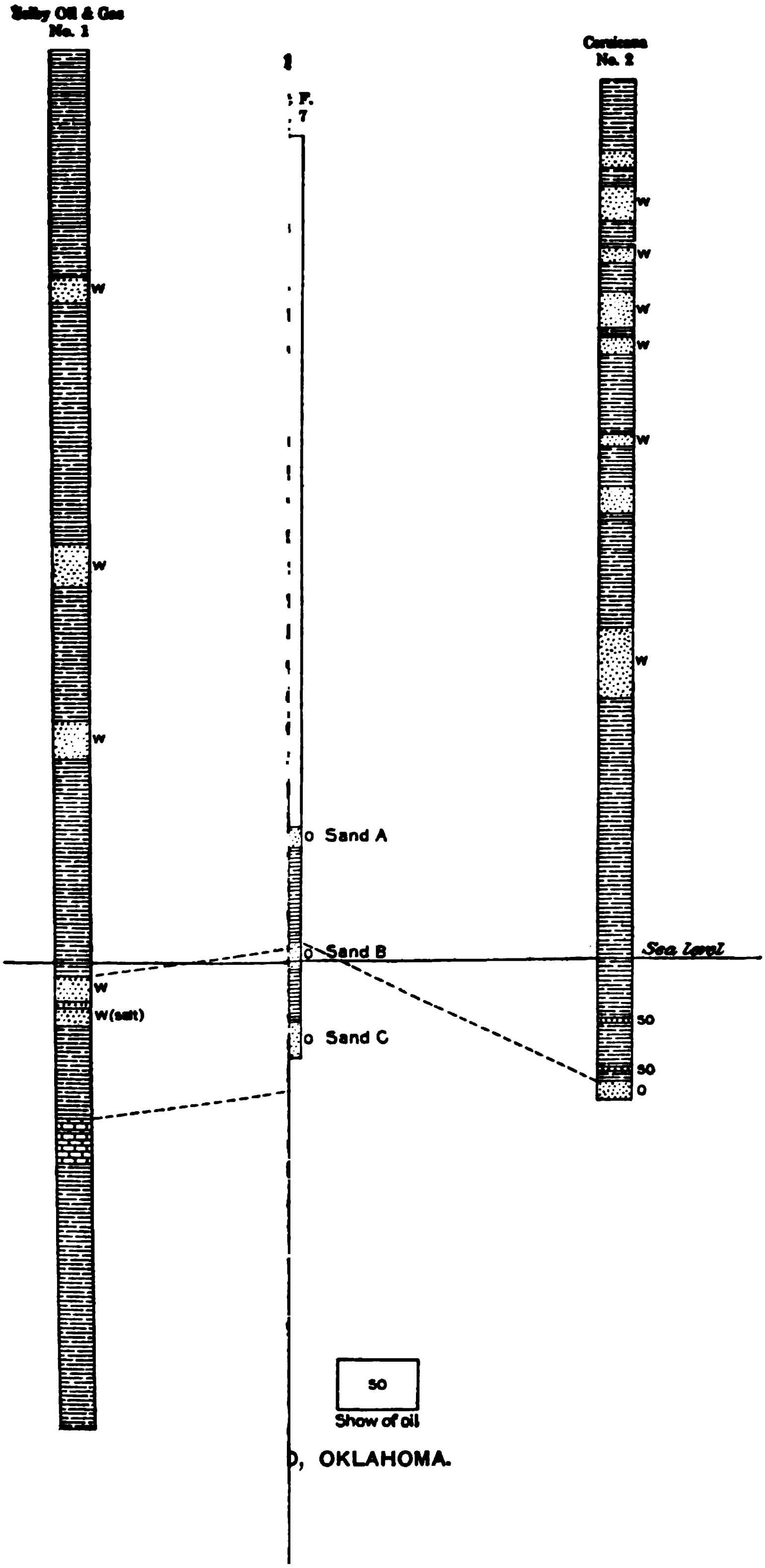
[1] Taff, J. A., Preliminary report on the geology of the Arbuckle and Wichita mountains, in Indian Territory and Oklahoma: U. S. Geol. Survey Prof. Paper 31, pp. 74-75, 1904.


Selby Oil & Gas
No. 1
F.
7
Corsicana
No. 2
W
W
W
W
W(salt)
o Sand A
o Sand B
o Sand C
W
W
W
W
W
W
Sea Level
SO
SO
O
SO
Show of oil

, OKLAHOMA.

were in all probability never covered by the Permian sea, there must have been less than 1,500 feet of Permian beds removed by erosion in the Lawton area. The rocks at the surface in the productive area at Lawton are probably about 500 feet stratigraphically above those at the surface in the Healdton field. It may be inferred, therefore, that from 1,500 to 2,000 feet of Permian beds have been removed by erosion from the central part of the Healdton dome, and as the plain on the crest of the Arbuckle Mountains, which was formed in pre-Cretaceous time, is only 400 feet higher than the surface at Healdton, it is evident that the greater part of the erosion of the Permian was accomplished prior to the Cretaceous period. As is shown in what follows, the Permian probably extends to a depth of 800 or 900 feet below the surface in the Healdton field, so that the thickness of the formation as originally deposited was probably about 2,500 feet.

As exposed along the Arbuckle Mountains, the contact of the Permian with the underlying beds is unconformable, the flat-lying Permian strata overlapping the edges of the steeply dipping Ordovician, Devonian, and Carboniferous rocks.[1]

Similar unconformable relations prevail along the Wichita Mountains, and there is evidence that the older rocks were rather deeply trenched by erosion before the Permian was deposited over them. The unconformity appears to be comparatively local in extent and to owe its origin to the Wichita-Arbuckle uplift, inasmuch as it does not appear in Clay County, Tex., where the contact of the Permian and the underlying Pennsylvanian is exposed. In the Texas region the Cisco, which is the uppermost formation of the Pennsylvanian, is, as far as appearances go, conformable with the Wichita, the lowest formation of the Permian, and it is, in fact, difficult to recognize the boundary between the two formations.[2] In the region between Clay County and the Wichita-Arbuckle uplift the base of the Permian is nowhere exposed.

In the Healdton field, which is about 12 miles distant from the Arbuckle Mountains, the well logs afford considerable evidence that the unconformity so conspicuous along the mountains is present. Limestone is practically absent from the first 800 or 900 feet of strata below the surface, but at greater depth in certain wells thick beds of limestone are encountered. (See Pl. IV.) The sandstone beds in the non limestone-bearing series can be correlated from well to well throughout the field by making due allowance for errors in recording the strata passed through in drilling. No break or unconformity in the series is apparent. Where, however, thick beds of limestone are encountered they appear to be at different horizons in different wells and bear no definite relation to the sandstone beds, as if separated from them by unconformity. Under these conditions it appears reasonable to assume that the shale and sandstone beds, predominantly red near the surface and gray or blue at depth, are of one age, the Permian, and that the thick limestone beds below, which alternate with light or dark gray shales and which seem to be separated from the overlying series by an unconformity, are older and presumably of Pennsylvanian age. The principal oil and gas bearing beds are, according to the above classification, near the base of the Permian.

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[1] Taff, J. A., op. cit., p. 72.

[2] Gordon, C. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, p. 19, 1913.

A tentative correlation between the strata of the Healdton and Loco fields seems to show that the gas-bearing sands at Loco are several hundred feet stratigraphically above the oil sands at Healdton. The facts on which this correlation is based are as follows: A little east of the center of sec. 21, T. 4 S., R. 3 W., is an outcrop of asphaltic sandstone similar in character to a rock which is exposed at numerous places in the Loco field, particularly in sec. 25, T. 3 S., R. 5 W., where it was at one time mined. The probable equivalent of the sandstone in sec. 25 is encountered at a depth of 40 feet in well No. 4 of the Oklahoma Diamond Oil & Gas Co., drilled in the SE. ¼ sec. 10, T. 3 S., R. 5 W. A comparison of the log of this well with that of well No. 1, drilled by the Red River Oil Co. on the Clydie Ingram farm, a little over half a mile west of the outcrop of asphaltic sandstone in sec. 21, T. 4 S., R. 3 W., shows considerable similarity, and it therefore appears possible that the asphaltic sandstone in sec. 21, T. 4 S., R. 3 W., represents the same bed that is exposed in the Loco field. This sandstone seems to have been encountered at a depth of 12 feet in the Clydie Ingram well.

The Clydie Ingram well is a dry hole, almost 2 miles southwest of the productive area at Healdton, and it is impossible to make accurate correlations between it and the Healdton wells. It seems probable, however, from a comparison of the logs, the known dip of the rocks from the Healdton dome toward the well in sec. 21 being taken into account, that the probable equivalent of one of the gas-bearing strata in the Loco field which was encountered in the Ingram well at 670 feet lies within 100 or 200 feet of the surface on the crest of the Healdton fold.

A general correlation of the beds exposed in the Healdton field with those appearing at the surface near Loco and also in the Duncan and Lawton fields may be made on the basis of a series of sandstones that constitute the surface rocks in the sandy wooded area northeast of the Healdton field. The same beds are found southwest of the field, where also they are timber covered. They appear to be the same as the sandstone beds that constitute the surface rocks from Loco north to the grahamite mines in sec. 6, T. 2 S., R. 4 W., and form the timbered ridge which runs from the vicinity of the grahamite mines northwestward to a point 4 miles southeast of the Duncan gas wells. It appears probable that the sandstone hills that lie just east of the Lawton oil and gas field are formed by this same sandstone, inasmuch as the next higher ridge-forming sandstone in the Lawton region is the same as the sandstone which forms the escarpment or rim rock of the Duncan gas field and which is the first prominent bed above the timbered sandstone series of the grahamite mines.

Except for a few plant remains the Permian beds in the Healdton field are unfossiliferous. Two small collections of leaves were obtained. They have been examined by David White, and his descriptions are given below.

SE. ¼ SW. ¼ sec. 4, T. 4 S., R. 3 W. Surface fragment of ferruginous sandstone containing plant remains. The fragment is filled with miscellaneous drifted and waterworn plant vestiges, many of which are small fragments belonging perhaps to the genus Walchia. Obscure remains of seeds are also present. This rock does not appear to contain conclusive evidence as to its age, though it is probably Paleozoic.

A number of small fragments obtained by breaking up a piece of reddish sandstone, rather coarse grained, contain drifted and somewhat waterworn bits of vegetation. The plant débris consists of very small pieces and is mostly so macerated or abraded as to render specific identification impossible.

The material includes fragments of a lobed pinnule which, from its form and nervation, probably belongs to Callipteris, a distinctly Permian genus. Several fragments of gymnospermous twigs apparently represent a species of Walchia, nearly related to if not identical with *Walchia gracilis* Daws. A very small fernlike fragment, with decurrent lamina, may be either Callipteris or Pecopteris. A peculiar fragment of a scale probably belongs to a fructification found in the Permian of the Southwest. It is very closely related to Noeggerathia. Two specimens containing portions of neuropteroid pinnules are comparable to *Neuropteris gleichenioides*. Portions of two seeds are recognized, one of them being probably referable to the genus Cardiocarpon.

There is scarcely room for doubt as to the Paleozoic age of the sandstone which contains this material, and, notwithstanding the extremely fragmentary character of the débris and the very small number of specimens, I do not hesitate to regard the beds as Paleozoic. The specific evidence indicates that the sandstone is probably Permian.

Two other fragments of sandstone accompany the collection just described. The larger fragment is strewn with comminuted plant débris, none of which is generically determinable, although it is probable that a number of megaspores are present. The small fragment contains a seed of the type referred to the genus Walchia. This seed is evidence of the Permian or latest Pennsylvanian age of the bed from which the specimens were obtained.

Fragments of sandstone the grains of which are cemented with chalcedony were seen at several places on the northwest flank of the Healdton dome. This sandstone resembles in every respect certain beds that are found in the Trinity sand, of Cretaceous age, where that formation is exposed along Red River, about 30 miles south of the Healdton field. Nowhere in Healdton was this sandstone noted in place, but about halfway between Hewitt and

Ardmore numerous blocks of it were found on a wooded knoll just north of the road. The blocks are only 4 or 5 inches in thickness and appear to be practically in place. The underlying shale is oxidized for a depth of about 2 feet, being rusty brown in color. It is possible that this sandstone is in reality of Cretaceous age and is the last remnant of a comparatively thin sheet of Cretaceous beds which were at one time spread over this country.

It is believed that prior to the deposition of the Cretaceous strata the land areas were reduced by erosion almost to a plain, which is now represented by the flat surface forming the crest of the Arbuckle Mountains. The sandstone outcrop on the Hewitt-Ardmore road, above mentioned, is about 200 feet below this plain on the Arbuckle Mountains, so that if these beds are in reality Cretaceous the plain must have been somewhat irregular in order to allow their deposition at a level considerably lower than that of the mountain area. The supposition that the beds are Cretaceous is supported only by lithologic similarity, which, however, in a rock of so peculiar a character should have considerable weight.

GEOLOGIC HISTORY.

As is evident from the nature of the Paleozoic rocks exposed in the Arbuckle Mountain uplift, conditions of sedimentation were almost continuous from the Cambrian to the close of the Mississippian. Slight oscillations of the sea floor probably took place, but were not of sufficient magnitude to produce any pronounced unconformity. At the close of Mississippian time an uplift of the mountain mass now represented by the Arbuckle Mountains occurred and a great lens of conglomerate of Pennsylvanian age, known as the Franks conglomerate, was laid down. Marine conditions were reestablished and continued during Pennsylvanian time, at the close of which the mountains were again uplifted and their surface was eroded into deep valleys. Once more the land subsided and was submerged, and the Permian deposits were laid down on this irregular surface.

At the close of the Permian epoch the whole region was uplifted with comparatively little folding, and apparently it remained a land area through Triassic and Jurassic time, the surface being reduced by erosion to a low-lying, comparatively level plain in which hard and soft rocks alike were removed and brought to one general level. At the beginning of the Cretaceous period this broad flat plain was tilted toward the southeast and the Cretaceous sea advanced upon it, spreading its deposits of sand, shale, and limestone over what had formerly been land. As the southeastern part of the plain subsided the northwestern part of it rose, and when conditions of stability were restored and erosion continued to act upon that part of the surface which remained above the ocean, the softer rocks of the ancient plain were reduced to lower levels, leaving the harder rocks, such as those that form the Arbuckle uplift, rising above the newly formed surface and preserving in their flat summits the former base-level. Erosion continued until a new plain was formed, and this plain is the notable feature of the present physiography of the greater part of Oklahoma. Over the surface of this plain rivers deposited thin sheets of gravel, and it is stated by Taff[1] that these gravel deposits, which lie in terraces along the courses of the present rivers, may be traced southeastward into the Tertiary area, where they merge with the Tertiary gravels of the Coastal Plain, showing that the gravel deposits and the ancient plain on which they were formed are probably of Tertiary age. The correlation of the gravel deposit of the plain with those of the coastal sediments may, however, be open to question, and the formation of the plain may be more recent than Tertiary. Since the formation of this plain a slight uplift of the region has occurred, and now the rivers are once more cutting their valleys below the plain which they formerly made. This cycle of erosion has not progressed far, and the new base-level that is slowly being formed is represented only by the flood plains of the larger streams.

INFORMATION AFFORDED BY WELL LOGS AND METHODS OF FIELD WORK.

In an oil field like that of Healdton, in which exposures of rock are very few, the outline of the structure must be determined in large measure from the data afforded by the logs of the wells drilled in the field. A clear appreciation of the nature of the data afforded by well logs is necessary in order to understand the degree of accuracy of the statements which follow and of the structure as outlined on the accompanying map.

In deep wells depths as usually measured are, because of the stretching of the drilling cable, accurate only within 5 or 6 feet. The change from shale to sandstone is not necessarily abrupt, and the sandstone may not be recognized until it has been penetrated for several feet. Very fine grained sandstone is easily mistaken for shale by one who is not accustomed to distinguish between the two, and certain drillers habitually call fine-grained sandstone shale or slate. Hard sandstone may be referred to as "lime," and limestone, if it is oil bearing, is sometimes mistaken for sandstone. Alternating beds of sandstone and shale may be regarded as unbroken sandstone. Certain drillers note only those sandstones that carry water, oil, or gas, and, as a consequence, the thicknesses of sandstone beds are often underestimated. In these circumstances accurate correlations between the strata recorded in the logs o adjacent wells are difficult, and sometimes impossible, but by careful comparison of all the logs available in a given field, it i usually possible to determine what beds are continuous over th area and to decide which of the records are inaccurate. Wher exact correlation between wells is impossible, the geologist mus rely on his judgment in representing the form of structure that i most likely to exist, and his results are of course subject to error.

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[1] Taff, J. A., op. cit., p. 17.

In the field work the locations and elevations of all wells in th field were determined by means of a plane table and telescopi alidade.

INTERPRETATION OF STRUCTURE CONTOURS.

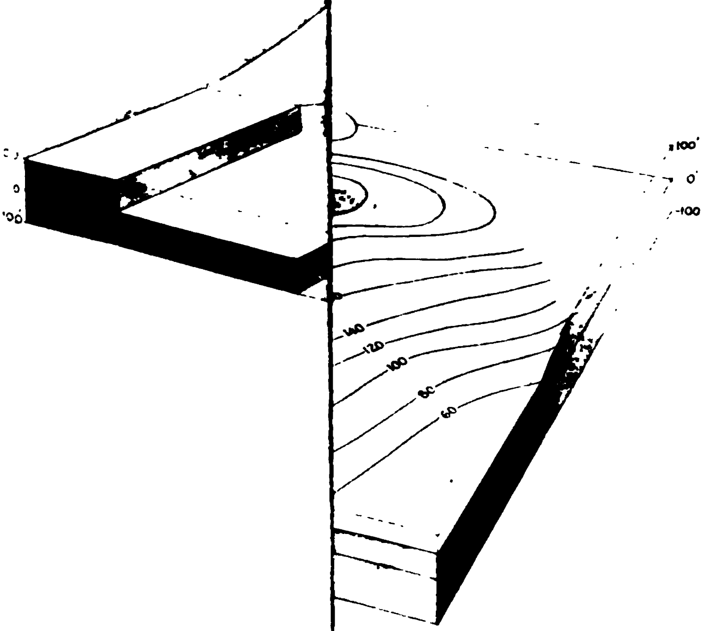
The structure contours given on Plate III are drawn on the sur face of the first main oil sand below the gas sand (B, Pl. IV) an represent the shape of the folded surface of that bed (see also Pl. V) Every point along any one line is at the same elevation above o below sea level, the lines being drawn at intervals of 20 feet. T one unfamiliar with the interpretation of contours the followin somewhat fanciful conception may be of assistance:

Were it possible to remove all the overlying strata and to wal about on the surface of the oil sand, the course followed by one wh endeavored to walk always at an elevation of 200 feet above the sea never stepping up or down, would be that indicated by the 200-foo contour on the map. When the pedestrian came to a knoll or juttin point, he would be compelled, if he did not wish to ascend, to walk around its side. When he crossed the valley which lay between thi knoll and the next he would be compelled, if he did not wish to descend, to walk up the valley to a point where its floor was level wit that of the hillside which he had just left. In other words, his cours were it represented by a line, would outline the form of the hills an valleys, or their contour.

A series of contour lines drawn at regular intervals above se level reveals very clearly, to one accustomed to reading contours the form of the surface which they represent. On the map (Pl. III the surface indicated by the contour lines is that of oil sand B o the columnar sections. To calculate the approximate depth to thi sand at any point in the field it is only necessary to obtain the elevation above sea level of the land surface at that point and to subtrac from it the elevation of sand B at the same point as shown on th map.

STRUCTURE.

The accumulation of oil at Healdton is situated on an irregula structural dome or anticline about 4½ miles in length by 2 miles in breadth, the long axis trending N. 62° W. (See Pls. III and V.)


+100'
-100'

The presence of the dome is not indicated by the topography. Superimposed on the fold are twelve or thirteen minor folds, the long axes of which appear to trend in general at right angles to the trend of the major fold. In the east half of the dome there are among the minor folds at least two oval depressions, which may be considered to be the reverse of the minor dome structures.

The extreme difference of elevation in the main dome, indicated by the altitude of the oil sands on its flanks and on the highest of the minor domes, amounts to about 400 feet, but the height of the entire dome, could it be measured at a greater distance from its central part, is probably considerably more than this. The amount of dip in different parts of the field varies greatly, ranging from 100 to 400 feet in a mile.

Near the corner of secs. 4, 5, 8, and 9, T. 4 S., R. 3 W., a fault trending in general parallel to the long axis of the major dome appears to be present. Its downthrow is to the north. It is possible that this structure may be an abrupt fold rather than a fault, but from the relations of the strata recorded in wells on both sides of it, as well as from the presence of the dry hole in the SE. ¼ SW. ¼ SE. ¼ sec. 5, the presence of a true fault is regarded as very probable. The abrupt fold shown in the south-central part of sec. 32 may be a fault rather than a fold and this probability is strengthened by the presence of two dry holes in the NW. ¼ NE. ¼ sec. 5.

As has already been stated, the Healdton pool lies about 12 miles southwest of the west end of the Arbuckle Mountain uplift. At a distance of 65 miles N. 72° W. from the Arbuckle Mountains lies the Wichita Mountain uplift, which is believed to be of the same age. Between these two uplifts the Permian beds are bent into a broad, low arch which is outlined on its north side by an escarpment of sandstone. This escarpment may be traced from a point north of Foster post office, which is northwest of the Arbuckle Mountains, to the Duncan gas field, thence north of the town of Duncan in a northwesterly direction to the north flank of the Wichita Mountains. The position of the south limb of the low arch between the two mountain uplifts has never been determined, as the rock exposures in the broad plains of this region are very few.

About 10 miles northwest of the Healdton dome is the Loco gas field, and 15 miles north and a little west of Loco is the gas field known as the Duncan field, which lies 10 miles northeast of the town of Duncan. (See fig. 3.) The three fields lie along a curve which appears to encircle the west end of the Arbuckle Mountains, forming, so to speak, a cross fold to the low arch which lies between the Arbuckle and Wichita uplifts. It is not meant to imply that the Healdton, Loco, and Duncan fields are situated on one long anticline. They are in fact three separate domes, but they lie in such a relation to one another as to suggest that they are more intimately connected in origin with the Arbuckle uplift than with the Wichita. The Duncan field lies north of the low arch between the two mountain uplifts, and the Loco and Healdton fields lie south of it.

Midway between the Healdton field and the Arbuckle Mountains is the dome or anticline on which is situated the Wheeler oil field, the axis of which appears to parallel that of the Healdton dome.[1] About 30 miles west and 8 miles south of the Healdton dome is an anticline exposed in the east bank of Red River, about 6 miles southwest of Waurika.[2] This structure is in alignment with the Devol anticline mapped and described by Munn[3] in the Grandfield district, farther west. The axis of this fold lies about 30 miles south of the Wichita Mountains and is in general parallel to the axis of that uplift. South of the line of the Devol anticline and the anticline which lies southwest of Waurika are the Burkburnett and Petrolia oil and gas fields, which are situated on domal or anticlinal structures.

It is apparent, therefore, on considering the structure of this general region as a whole, that the Permian beds have been thrown into a series of waves or undulations such as might have been caused by stresses acting between the rigid mass of the Arbuckle and Wichita mountains and the strata of the plains region. That subsequent stresses have acted in directions oblique or at right angles to those which produced the major folds is indicated by the relations of the axes of minor domes, such as those which occur in the Healdton field, to the axes of the larger structures on which they are superimposed. It is possible that the time of the formation of the folds that are now occupied by oil and gas pools was coincident with the uplift of the region which followed the formation of the supposed Tertiary plain. (See p. 21.) In Cotton County, southwest of the Healdton field, the adjustment of the minor streams to folds is very exact, and it is probable that the time of folding has been comparatively recent.[4]

OCCURRENCE OF OIL AND GAS.

Oil and gas in the Healdton field are found in many sandstone strata of the "Red Beds," but the principal deposits from which they are obtained lie in three or more sandstone beds which form, together with the interbedded shale, an oil-bearing zone about 250 feet in thickness. The top of this zone is found from 600 to 950 feet below the surface. In general the highest of the sandstone beds (A, Pl. IV) is the gas-bearing sand, although gas occurs in considerable amount in the lower sands, and the gas sand in certain wells produces a considerable amount of oil. From this sand also, on the flanks of the fold, below the oil and gas horizon, salt water is reported. The next sand below the gas sand (B, Pl. IV) is that on the surface of which the structure contours of Plate III are drawn. The oil in this sand is often, though not invariably, lighter than that of the lowest sand (C, Pl. IV). This lowest oil sand is not reached in all the wells but appears to be as rich in oil as sand B. Certain wells that have been drilled to considerable depths have encountered below this sand thick beds of limestone which alternate with dark shale, and which are probably of Pennsylvanian age.

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[1] Snider, L. C., Petroleum and natural gas in Oklahoma, p. 144, 1913.

[2] Wegemann, C. H., Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, pl. 5, 1915.

[3] Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, 1914.

[4] Wegemann, C. H., op. cit., p. 34.

Oil, when found in the beds above the principal oil and gas zone, is of high specific gravity, containing considerable amounts of asphalt. Salt water is rarely, if ever, recorded from the strata above the principal oil-bearing zone, but it is found in the strata of that zone on the flanks of the fold below the oil pool, and in some wells—as, for example, Woodward No. 4 of the 1911 Oil Co., in sec. 32, T. 3 S., R. 3 W.—it is reported from strata below those which carry the oil.

The lower limit of the oil pool is by no means at the same elevation with reference to sea level on all sides of the dome. In the SE. ¼ SE. ¼ sec. 36, T. 3 S., R. 4 W., oil is encountered at sea level, and in the SE. ¼ SE. ¼ sec. 6, T. 4 S., R. 3 W., the oil-bearing zone was found barren at 190 feet above sea level. In the shallowest part of the Healdton pool, on the crest of the dome, oil is obtained at 380 feet above sea level, or 600 feet below the surface. The wells which show the greatest quantity of gas are, as a rule, situated on the crests of the minor domes (Pl. III). This does not appear to be true of the wells just northeast of the center of sec. 5, as shown on Plate III. It should be stated, however, that logs of the Wrightsman and Foster wells, just northeast of the wells mentioned, were not obtained, so that the details of the structure in this particular area are not known and the mapping may be somewhat inaccurate.

The general character and fractional composition of the Healdton crude oils are indicated in the accompanying tables, which are extracted from a report on "Conditions in the Healdton oil field," submitted by Jos. E. Davies, Commissioner of Corporations, to the Secretary of the Department of Commerce, March 15, and published by the department under that date. According to this report the Healdton oils range in gravity from 29.27° to 33.93° Baumé. The variation does not appear to have any direct relation to the structure. Oils of different gravity that are obtained from adjacent wells come, as a rule, from different sands. In general, the oil in the Healdton pool is darker in color than oil of the same gravity in other fields.

The analyses made by G. Y. Williams and C. K. Francis show gasoline, and those made by M. C. Whitaker show naphtha.

The two samples examined by Mr. Whitaker for the Bureau of Mines (see pp. 103–107 of the report cited) were subjected to fractional analyses by four methods, with corresponding variation in the results, as shown in the second table. These samples were taken at the localities indicated below:

1470. Lease, Silsanny Jones Allot—Dept. lease: Sec. 4, T. 4 S., R. 3 W., Carter County, Okla.; owner, Coline Oil Co., Ardmore, Okla.; well No. 1. Sampled by Irving C. Allen, May 23, 1914.

1464. Million & Thomas farm: Sec. 5, T. 4 S., R. 3 W., Carter County, Okla.; owner, Crystal Oil Co., Ardmore, Okla.; well No. 3 at extreme southeast corner of S. ½ SE. ¼. Sampled by Irving C. Allen, May 23, 1914.

Concerning these results Mr. Whitaker adds:

> A comparison of the results obtained shows a wide discrepancy in amounts of the various products obtained by the several methods of analysis, and this difference is especially great in the case of the "naphtha." On sample No. 1464 about one and three-fourths times as much "naphtha" is obtained by the Engler method as by the Regnault method, whereas in sample No. 1470 the "naphtha" obtained by the Nawratil method is less than one-third that obtained by the Engler method. The variations shown in the analysis of your oils by the different methods are directly in accord with our previous experience, extending over a number of years. We do not consider any of the existing methods as dependable. It is doubtful if any of these methods will give results even approximating those attained in practical distillation.

Information as to laboratory barrel-still tests, as to sulphur content, and as to products, etc., will be found in the report of the Commissioner of Corporations.

The largest production from single wells, amounting in one well to 5,700 barrels a day, is obtained on the minor dome in the N. ½ sec. 6, T. 4 S., R. 3 W. This dome is not the highest one in the field, but it appears to be one of the most regular, and the question may here arise as to whether the more intense folding that has taken place in certain parts of the Healdton dome has tended to close the pores between the sand grains, making the sands less porous and reducing their capacity to hold oil. The two dry holes in the NW. ¼ NE. ¼ sec. 5, T. 4 S., R. 3 W., may perhaps be accounted for in this manner or on the possibility of a fault existing at this locality. (See p. 23.) The dry hole in the SW. ¼ SE. ¼ sec. 5 is probably due to the presence of the fault indicated on Plate III. A fault of this nature may interrupt an oil-bearing bed, causing an accumulation on one side of the fault, whereas the beds on the opposite side are left barren of oil.

SOURCE OF THE OIL.

The oil in the Healdton field has probably been derived from the Pennsylvanian rocks underlying the Permian, near the base of which the oil is found. There is, however, no direct proof of this assump-

Test made by—	Wi	Lubricating oils.		Residuum.		Coke.	Loss.	Total.
		Gravity.	Per cent.	Gravity.	Per cent.			
		° *Baumé.*		° *Baumé.*		*Per ct.*	*Per ct.*	*Per ct.*
G. Y. Williams:								
No. 1	No	....	....	32.5	48.0	5.0	(c)	100
No. 2		....	....	32.5	48.2	5.5	(c)	100
No. 3	Ol	....	....	32.5	47.0	6.1	(c)	100
No. 4	O	....	....	20.4	53.9	....	(d)	100
C. K. Francis:								
No. 1	St	35.0	7.0	20.2	37.2	....	0.5	100
No. 2		34.2	16.0	20.6	41.7	....	.0	100
L. Kirschbraun	Ch	26.4	12.5	15.2	32.5	....	(d)	100
M. C. Whitaker:								
Sample 1470—								
No. 1 [g]	Ne	28.0	52.9	....	....	3.5	1.6	100
No. 2 [h]		29.1	56.0	....	....	4.8	1.7	100
No. 3 [i]		29.8	56.0	....	....	3.9	1.6	100
No. 4 [j]		29.1	57.5	....	....	4.0	1.7	100
Sample 1464—								
No. 1 [g]		27.7	50.5	....	....	2.6	1.9	100
No. 2 [h]		28.7	53.5	....	....	3.1	1.1	100
No. 3 [i]		29.2	53.5	....	....	2.7	3.1	100
No. 4 [j]		30.8	52.5	....	....	4.8	1.4	100
Bureau of Mines, average of 20 tests.	Pi	29.9	29.4	....	32.9	....	(d)	100

[a] All results are b
[b] 100 c. c. equals
[c] Loss included i
[d] Loss included i
[e] Presence of asp
[f] Weighted aver
gravity, 13.3 per cent
7.0 per cent for test N

nt of paraffin wax can be obtained. (Testimony of I. C.

	Nawratil method.			
	Sample 1470.		Sample 1464.	
	lume (per ent).	Specific gravity at 60° F.	Volume (per cent.)	Specific gravity at 60° F.
B	2.8	0.7556	11.1	0.7372
1	11.5	.7750	8.6	.7774
2	11.3	.8049	10.5	.8059
2	11.2	.8322	11.1	.8351
A	57.5	.8798	52.5	.8705
C	4.0	....	4.8	....
L	1.7	....	1.4	....

flask at 50° C.

d 300° C. as "illuminating oils;"
th er. Bracketed items have been
ins

Sample 1464.		
Ubbelohde.	Regnault.	Nawratil.
Per cent.	*Per cent.*	*Per cent.*
11.5	9.5	11.1
30.8	31.2	30.2
53.5	53.5	52.5
3.1	2.7	4.8
1.1	3.1	1.4
100.0	100.0	100.0

tion. It is usually admitted that the Pennsylvanian beds, which contain more plant and animal remains than the beds of the Permian are the more probable source of oil, and in the great fields of northern Oklahoma the oil is obtained from Pennsylvanian strata. It is therefore usually assumed that oil found in the beds of the Permian has been derived from the underlying Pennsylvanian.

East of the Arbuckle Mountains beds of Ordovician age are known to be asphalt bearing in the vicinity of Atoka.[1] The asphalt deposits formerly mined near Woodford, 10 miles northeast of the Healdton field, however, occur in Carboniferous strata. It seems probable that the limestones underlying the Permian in the Healdton field are of Pennsylvanian age, inasmuch as the strata occupying a similar position in the Loco field have yielded Pennsylvanian fossils in the drill cuttings from the gas wells; yet there is a remote possibility that the limestone beds in the Healdton field may be older than Pennsylvanian and perhaps Ordovician.

If, as is believed by some authorities, the formation of petroleum from plant or animal remains is due to the action of bacteria, it is evident that the transformation to petroleum must take place soon after the deposition of the sediment. If the folding which produced such structure as that of the Healdton dome has taken place in comparatively recent time, it is evident that the oil, the accumulation of which is undoubtedly due to the presence of the rock folds, has been collected in its present position since the folding, or at a time long after the formation of the oil. It must then have existed through the ages as minute globules scattered through the Pennsylvanian rocks, or collected in some fold of the Pennsylvanian from which, after subsequent erosion, deposition of the overlying beds, and folding, it migrated into the strata of the Permian.

To the writers it seems more probable that the organic compounds, whether of vegetable or animal origin, from which the oil was eventually formed, existed as minute particles in shale or limestone. Recent microscopic studies by Davis[2] have demonstrated the presence in the "oil shales" of Colorado of the remains of algæ in great numbers, and there appears to be little doubt that the compounds in this shale, which on distillation give petroleum, are derived, in part at least, from these algal remains. The shales of the Carboniferous were probably not so highly impregnated with organic material capable of producing oil as the typical oil shales, yet their mass is so great that even with a comparatively low percentage of organic material they might be capable, under proper conditions of temperature and pressure, of generating vast stores of petroleum. Such conditions may well have been supplied by the earth movements that produced the folds in which the oil accumulated, the organic material in the shale undergoing slow distillation under conditions of high pressure and of the temperatures induced by the pressure. The product of such distillation may have been petroleum, or it may have been gas from which on condensation petroleum was formed. Gas passes through rock pores with little friction as compared with oil, and many accumulations of petroleum which are accounted for with difficulty on the supposition that petroleum as such migrated for considerable distances through the rock strata are easily explained by supposing that the petroleum reached its place of accumulation in the form of gas, which later condensed to petroleum. Whatever the method of formation of the oil and the conditions under which it was collected into pools, it is certain that in such fields as that of Healdton the presence of domal or anticlinal structure in the rock beds has been the controlling factor in determining the place of accumulation.

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[1] Taff, J. A., Grahamite deposits of southeastern Oklahoma: U. S. Geol. Survey Bull. 380, p. 296, 1909.

[2] Davis, C. A., On the fossil algæ of the petroleum-yielding shales of the Green River formation: Science, new ser., vol. 41, No. 1059, Apr. 16, 1915.

FUTURE DEVELOPMENT IN THE HEALDTON FIELD.

The productive area of the Healdton oil field has already been defined in a general way by the drill, but there still remains much undeveloped territory to be explored. The drilling already done shows that the oil sands are productive in practically all parts of the dome above the 200-foot contour—that is, within the area encircled by it, as shown on Plate III. In this area only one dry hole has been drilled. This was located on the line of a probable fault, and it may reasonably be inferred that when fully explored the entire area outlined by the 200-foot contour will be found productive. Greater gas pressure and consequently higher initial production will probably be encountered near the crests of the subsidiary domes, as shown on Plate III, than in the depressions between them.

A most promising place for an extension of the producing territory is in the NW. ¼ SE. ¼ sec. 31, T. 3 S., R. 3 W. A well has already been drilled in the southwest quarter of this 40-acre tract, but the axis of the subsidiary dome on which it is situated extends from the well in a northeasterly direction—how far has not yet been determined.

Similar conditions exist on the subsidiary dome whose highest part lies just north of the center of sec. 6, T. 4 S., R. 3 W., and on which some of the best wells in the field have been put down. The axis of this dome, as shown on Plate III, extends in a southwesterly direction from a point just north of the center of sec. 6, but the extent of the structure to the southwest has not been determined. The fact that dry holes were put down in the SE. ¼ SE. ¼ sec. 6 and the SE. ¼ NW. ¼ sec. 7 should not condemn the territory along the axis of this dome southwest of the center of sec. 6. In testing this territory, as well as that in sec. 31, T. 3 S., R. 3 W., wells should be drilled on the anticlinal axis at intervals of one-eighth of a mile, beginning near the productive wells.

Some areas outside of the 200-foot contour, as shown on Plate III, have already been proved to be productive territory. The dry hole near the center of the SE. ¼ SE. ¼ sec. 36, T. 3 S., R. 4 W., tends to condemn the territory beyond the productive wells at the northwest end of the pool, but the area east of these wells, although it is outside of the 200-foot contour, will probably prove to be oil producing.

Wells drilled near the east quarter corner of sec. 10, T. 4 S., R. 3 W., are not large but appear to indicate an extension of the pool in that direction, and the territory between them and the main dome to the west probably contains oil.

An extension of the productive territory is to be expected south of the small dome in the SW. ¼ NW. ¼ sec. 10, T. 4 S., R. 3 W., in line with its axis, and this territory may extend as far south as the productive well already drilled in the SW. ¼ SE. ¼ sec. 15. Recent development in the vicinity of this well, however, shows high gas pressure, which may indicate the presence of a subsidiary or separate dome. Should such a dome be present at this distance from the main dome there is a possibility that an oil pool accumulated in it is entirely separate from that of the main dome, in which case part of the territory between it and the main dome is probably barren.

A producing well is located near the northeast corner of sec. 16, T. 4 S., R. 3 W., and the territory between it and the small dome half a mile to the northwest appears promising.

At other places around the dome the limits of the oil pool are at present fairly well defined by dry holes. The producing territory will probably be extended for very short distances at many places, but prospecting should be done cautiously by wells drilled comparatively near those already producing.

The oil and gas development in the southern part of sec. 15, T. 4 S., R. 3 W., suggests the possibility of finding other oil pools in the vicinity of the Healdton pool. To judge by the steep dip to the southwest in the S. ½ sec. 8, T. 4 S., R. 3 W., and the dry holes which have been drilled in this locality, the chances of finding oil immediately southwest of the Healdton pool seem to be poor. The territory between the Healdton pool and the asphalt deposits in sec. 32, T. 3 S., R. 4 W., has been by many operators considered as favorable ground for oil prospecting, but the fact that dry holes have been put down in secs. 32 and 36 is against this view. The surface rocks between the northwest end of the Healdton field and the asphalt deposits belong to the sandy series which overlies the beds exposed on the Healdton dome, and the structure in this area is therefore probably synclinal and not favorable to oil accumulation. Except for the possible extension of producing territory in sec. 31, T. 3 S., R. 3 W., the area immediately north of the Healdton field does not appear promising.

In the vicinity of the Healdton field the best chances for the extension of the producing territory or the discovery of new domes appear to be in the areas mentioned above and in the Permian area for a distance of 4 or 5 miles east and southeast of the field. About 8 miles east of the field the older Paleozoic rocks reach the surface and the oil-bearing beds at Healdton are not present, having been removed by erosion.

THE LOCO GAS FIELD, STEPHENS AND JEFFERSON COUNTIES, OKLAHOMA.

By Carroll H. Wegemann.

INTRODUCTION.

The Loco gas field is on the line between Stephens and Jefferson counties, Okla., about 3 miles southwest of the village of Loco and 10 miles northwest of the Healdton oil field. (See Pl. VI and fig. 3.) It is 18 miles east of the line of the Chicago, Rock Island & Pacific Railway. For many years asphalt deposits have been known to exist in this vicinity, but deep drilling for oil and gas was not begun until 1912. The first gas well was struck in the spring of 1913, about six months before the Healdton pool was discovered. Six other gas wells of capacities ranging from 6,000,000 to 20,000,000 cubic feet a day have been drilled, but no pipe line has yet been laid to the field and the wells are capped.

The field work on which the following report is based was done in November, 1913, the writer being assisted by Mr. R. W. Howell, of whose aid, both in the field and in the office, he desires to express his appreciation. The report has been prepared under a cooperative agreement between the United States Geological Survey and the Oklahoma Geological Survey, according to which each organization furnished a part of the funds necessary for the work.

Thanks are due to the Oklahoma Diamond Oil & Gas Co., the Washita Gas & Fuel Co., and Messrs. McQueen Bros. for logs of their respective wells; also to Mr. M. M. Hightower, Mr. W. J. Collier, and other residents of the district, who supplied valuable information and extended courtesies during the prosecution of the field work.

HISTORY OF DEVELOPMENT.

For many years asphalt seeps have been known to exist along a belt of territory lying southwest of the town of Loco, in Stephens County, Okla., and extending in a general northwesterly direction. In 1903 an unsuccessful attempt at development of the asphalt deposits was made by the Tar Springs Refining Co., whose works were built just south of the center of sec. 25, T. 3 S., R. 5 W. The refinery burned down soon after operations were begun, and current report states that owing to the lack of transportation facilities the venture would not in any event have been profitable. The same company drilled a well 1,000 feet northeast of the pit from which the asphalt-bearing sandstone was obtained, but apparently met with no success. It is reported that the well is not more than 600 or 700 feet deep.

R. V. LeGrande, of the Tar Springs Refining Co., after the bu of the asphalt plant, opened mines on grahamite deposits in se T. 2 S., R. 4 W., 6 miles north of Loco, which for a time were wo with profit. He was also instrumental in putting down a dug in search of oil near the south quarter corner of sec. 10, T. 3 S., W., about a quarter of a mile north of a water well in which as was encountered. The well was 142 feet in depth and by b twice daily would produce about 3 barrels of dark, heavy oil eve hours. The product was used in the vicinity as lubricating oil.

Deep drilling in the Loco field was begun by the Oklahoma Dia Oil & Gas Co. in October, 1912. The first well was drilled in s T. 3 S., R. 5 W., and encountered traces of oil and gas, but n quantities sufficient to warrant development. Four other wells drilled by the same company in the spring of 1913 in secs. 10 an T. 3 S., R. 5 W. All obtained gas under heavy pressure, the estim capacity of the wells ranging from 6,000,000 to 20,000,000 cubic f day. About the same time the Washita Oil & Gas Co. drilled a w sec. 15 which had a daily capacity of 15,000,000 cubic feet. McQ Bros. drilled in the SW. ¼ sec. 3 of the same township but obtained a showing of oil. The Oklahoma Diamond Oil & Gas Co. drilled du the winter of 1913–14 a well in the NW. ¼ SW. ¼ sec. 14, T. 3 S. 5 W., which obtained a little heavy oil, but no gas in comme quantity. During 1914 the same company drilled a dry hole in NE. ¼ NE. ¼ sec. 10, T. 3 S., R. 5 W., a gas well in the NW. ¼ N sec. 15, T. 3 S., R. 5 W., and an oil well near the middle of sec. 9, S., R. 5 W. This last-named well is reported to yield about 25 ba of heavy petroleum daily, as well as gas in considerable quantity.

The Nippon Oil Co. is at the time of writing (April, 1915) dril a well in the NE. ¼ SE. ¼ sec. 26, T. 3 S., R. 5 W.

LOCATION OF THE LOCO GAS FIELD WITH REFEREN TO THE HEALDTON OIL FIELD.[1]

As stated above, the wells in the Loco field are in secs. 9, 10, 15, T. 3 S., R. 5 W., but outcrops of asphalt-bearing sandstone occu a belt of territory having a maximum width of 3½ miles and extend from sec. 32, T. 3 S., R. 4 W., northwestward as far as the SE. ¼ 31, T. 2 S., R. 5 W., a distance of about 9 miles.

The northwest end of the Healdton pool lies in sec. 36, T. 3 S., 4 W., 9 miles southeast of the gas wells at Loco and 4 miles east the nearest asphalt deposits in the Loco dome. (See fig. 3.)

Between the two fields is an area extending from the NE. ¼ SE. sec. 36, T. 3 S., R. 4 W., to the SE. ¼ NE. ¼ sec. 32, of the same tow ship, a distance of 4 miles, in which there are no surface indicatio of petroleum and in which the wells already drilled have failed encounter oil or gas.

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[1] See pp. 13–30 of this bulletin.

TOPOGRAPHY.

Loco is on the southwest edge of a belt of sandy wooded country which borders the Arbuckle Mountains. The territory is rather more rolling than that of the treeless plains farther west, but the relief does not exceed 150 feet. The drainage of the Loco field is effected by branches of Mud Creek, a tributary of Red River.

STRATIGRAPHY.

The rocks exposed in the Loco field are of Permian age and consist of sandstone, shale, and fine conglomerate. The rocks lie stratigraphically lower than the beds that are exposed on the surface of the plains region a few miles farther west and are considerably more sandy. The following section of the lowest rocks exposed in the Loco field, which was measured near the crest of the anticline in the SW. ¼ sec. 24, T. 3 S., R. 5 W., will give a general idea of the nature of the rocks exposed, particularly the asphalt-bearing beds.

Section of rocks exposed in the SW. ¼ sec. 24, T. 3 S., R. 5 W.

Top.	Feet.
Sandstone, coarse, buff, or brown, composed of quartz, feldspar, zircon, and a highly altered manganese (?) mineral. Cement brown to opaque; some grains well rounded, others angular. Average diameter of grains, 0.303 millimeter	18
Shale, blue	3
Shale, red (poorly exposed); about 3 feet above the base fragments of very dark ferruginous sandstone lying on surface of outcrop	35
Shale (?); near the top are great numbers of round and irregular-shaped pebbles resembling concretions apparently derived from a bed of shale conglomerate similar to those described by various authors as occurring in the Wichita formation[1]	5
Sandstone, impregnated with asphalt; weathers white	3
Sandstone, calcareous, mottled gray and brown; weathers into large rounded forms, black on surface. Consists of quartz with apatite and rutile inclusions, zircon, and plagioclase; quartz grains somewhat separated from one another, subangular. Cement calcite, parts of which are very impure, giving rise to the mottled appearance	5
Sandstone, greenish white, thin bedded, fine grained. Cement calcite. Some of the layers carry a little asphalt	5
Shale, red and gray	3
Sandstone, cross-bedded, greenish white to black, according to the nature of the cement, which in some layers is calcite and in others entirely asphalt. Consists of quartz, with apatite and rutile inclusions, zircon in comparatively large amount, muscovite, and hornblende (?). The quartz grains are in some specimens separated from one another as if forced apart by the crystallization of the calcite forming the cement between them	5
Shale conglomerate containing pebbles which resemble concretions, bluish gray	⅙
Shale, red.	

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[1] Udden, J. A., and Phillips, D. McN., A reconnaissance report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.: Texas Univ. Bull. 246, Austin, 1912.

Overlying the rocks described in the above section are those which form the surface in the timbered belt northeast of the Loco anticline. These consist of alternating beds of shale and sandstone in about equal amount. The sandstone beds are for the most part white, bluish white, or gray, but are in some places red. The rock is comparatively coarse grained, some thin beds being conglomeratic and the individual grains being well rounded. The cement is calcareous. The character of the beds is shown by the following stratigraphic section, which was measured in a deep valley between the old grahamite mines in sec. 6, T. 2 S., R. 4 W., 6 miles north of Loco.

Section of rocks exposed near grahamite mines in sec. 6, T. 2 S., R. 4 W.

Top.	Feet.
Sandstone, white, with brown ferruginous layers	15
Sandstone, white, flecked with brown. Under the microscope shows quartz with rutile and apatite inclusions, altered feldspar, zircon, and tourmaline	15
Cement calcite. Brown specks, probably manganese. Average size of grain 0.126 millimeter	10
Covered; near top 2 to 4 feet of brown ferruginous sandstone, forming ledge	22
Sandstone, buff	2
Covered	20
Sandstone, white; upper part calcareous	6
Sandstone, bluish black, coarse. Contains small round concretions the size of buckshot, which weather out on surface, apparently of same material as mass of the rock. On extraction with chloroform, yields asphaltic oil in considerable amount	12
Sandstone, dark brown, coarse. Color probably due in part to content of manganese oxide. Upper part of bed cream-color streaked with dark brown	9
Conglomerate, pebbles of blue shale, cemented by calcite, hard, dolomitic	½
Sandstone, brown and black	3
Shale, blue	18
Sandstone, white, buff, and brown, hard; calcite cement; contains round pyrite concretions as much as 2 inches in diameter. The basal layers are irregularly impregnated in streaks and patches with petroleum, of which the rock smells strongly. The upper layers of the ledge are shaly and cross-bedded. The bed resembles in many respects the lower asphalt-bearing sandstone exposed in sec. 24, T. 3 S., R. 5 W	10
Conglomerate, pebbles of blue shale cemented by calcite; a shade of red in some layers	2
Shale, blue, sandy, blotched with red. Base not exposed.	

The sandy series is about 300 feet thick and forms a marked feature of the Permian over a considerable area. It constitutes the surface rocks in the wooded country northeast of the Healdton field as well as the high divide in the vicinity of the grahamite mines. This divide may be traced northwestward to the "base line road" 5 miles southeast of the Duncan gas field,[1] and it is probable that the low hills that partly encircle the Lawton oil and gas field,[2] 50 miles farther west, are formed by this same sandy series.

Fossil plants have been collected in the vicinity of Dixie, 6 miles east of Loco, from the red shale and fine-grained sandstone within or below the sandy series just described and have been determined by David White as probably of Permian age.

Knowledge of the strata underlying the surface in the Loco field is furnished by the logs of the deep wells. The beds consist of alternating shale and sandstone to a depth of about 800 feet. The red shale extends to depths ranging from 500 to 700 feet, the shale below being prevailingly blue or gray. The sandstone beds in the series just described appear to be fairly continuous over the area and by means of them the logs of the various wells may be correlated. Below this series, which is believed to be of Permian age, lie thick beds of blue or black shale alternating with beds of limestone. The rocks include also beds of sandstone, but the section as recorded in the logs of three of the deeper wells varies greatly, as if different parts of a rock series were penetrated in different wells. This series is believed to be of Pennsylvanian age, which is indicated by certain fossils obtained in the drill cuttings in some of the deeper wells, and is supposed to lie unconformably below the Permian strata. If the Pennsylvanian beds here dip at a considerable angle it is evident that wells put down at different localities will not encounter equivalent beds, and that the variations noted in the well logs are thus easily accounted for. The precise line of demarcation between the Pennsylvanian and the overlying Permian can not be determined, but it probably lies within 200 feet of the sand that in the productive wells is the principal gas horizon. In well No. 6 of the Oklahoma Diamond Oil & Gas Co. (No. 8 on Pl. VII), for example, it would appear to lie somewhere between 650 and 850 feet below the surface, possibly just above the 25 feet of limestone recorded at 860 feet. In well No. 7 of the same company (No. 5 on Pl. VII), which is about a mile northwest of well No. 6, this limestone is not recorded, and in well No. 1 of the Oklahoma Diamond Oil & Gas Co. (No. 1 on Pl. VII), which is 3 miles northwest of No. 7, the beds between 1,086 and 1,461 feet are for the most part limestone.

The unconformity noted in the wells of the Loco field may be well observed along the west end of the Arbuckle Mountains, about 15 miles northeast of the field. Here the horizontal Permian beds lie unconformably on steeply dipping strata ranging in age from Ordovician to Carboniferous, and the same general condition may be seen along the Wichita Mountains, which lie 50 miles northwest of the

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[1] See pp. 43-50 of this bulletin.

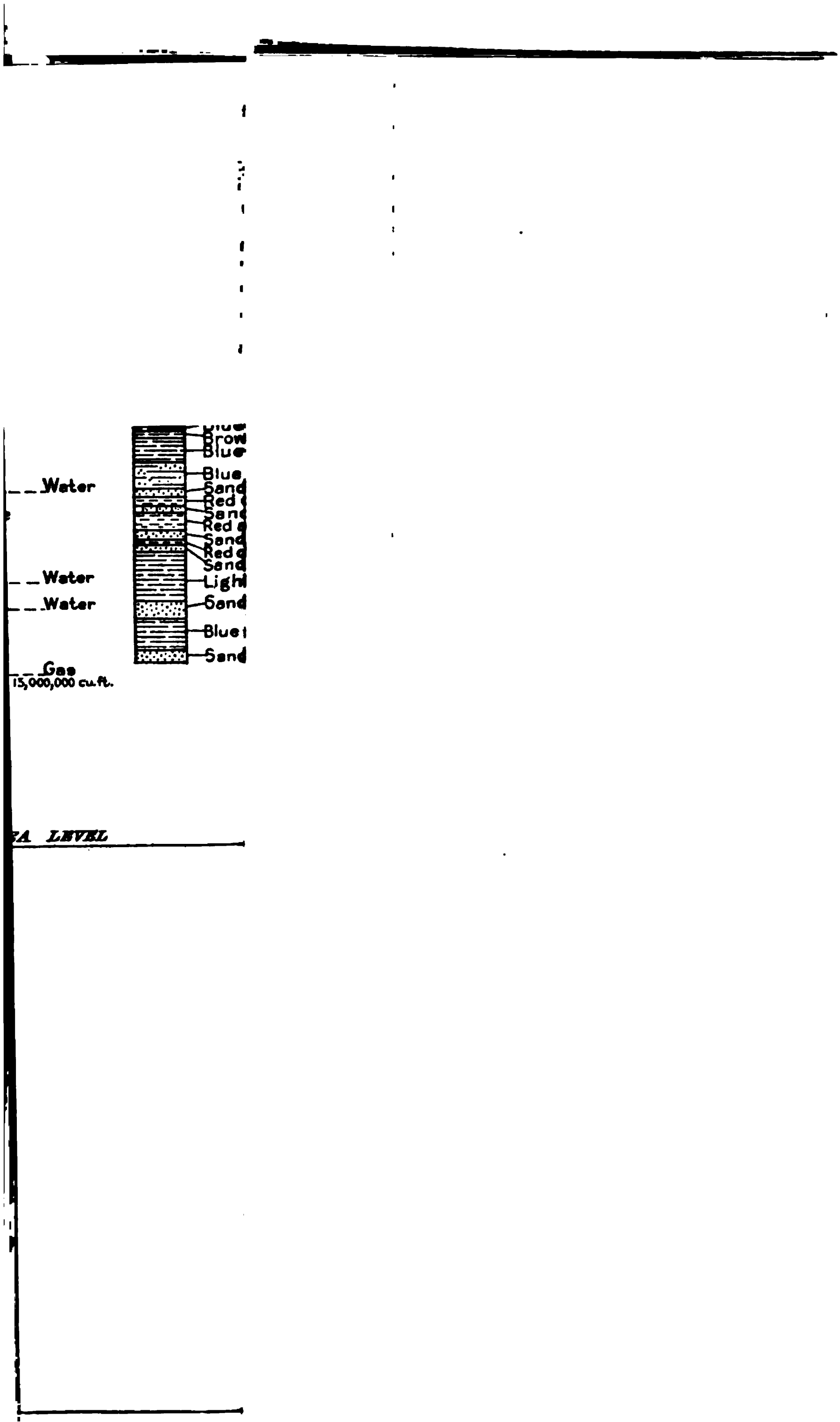
[2] See pp. 71-85 of this bulletin.

Arbuckle Mountains. This unconformity between the Pennsylv
and the Permian appears to have been only local in extent,
north-central Texas, where the same rocks are exposed at th
face, the Cisco formation, the highest division of the Pennsylv
appears to be perfectly conformable with the overlying Permian
Somewhere between the Arbuckle-Wichita uplift and the Texa
the unconformity which exists along the mountains must disa
but the Loco field is evidently well within the area affected
A tentative correlation between certain well logs of the Loc
Healdton fields seems to show that the gas-bearing sands at
lie within 200 feet of the surface on the crest of the Healdton
As most of the oil at Healdton is found in Permian strata at a
of 800 or more feet below the surface, it is evident that the Pe
beds at Healdton are lower than any represented at Loco an
the Permian in the Healdton field as originally deposited was
what thicker than in the Loco area. The surface on which th
mian beds were deposited appears to have been one of conside
relief, and variations in the thickness of the Permian are pro
due to the irregularities of the old land surface.

INTERPRETATION OF STRUCTURE CONTOURS.

The structure contours given on Plate VI are drawn upon the
face of the main gas sand (see Pl. VII) and represent the slo
the folded surface of that bed. Every point along any given
tour is at the same elevation above or below sea level, the
being drawn at intervals of 20 feet. To one unfamiliar with
interpretation of contours the following somewhat fanciful
ception may be of assistance.

Were it possible to remove all of the overlying strata and to
about on the surface of the oil sand, the course followed by one
endeavored to walk always at an elevation of 200 feet above
level of the sea, never stepping up or down, but walking always at
one level, would be that indicated by the 200-foot contour on
map. When the pedestrian came to a knoll or jutting point,
would be compelled, in order to keep at the same level, to walk aro
its side. When he reached the valley which lay between this k
and the next he would be obliged to walk up the valley to a p
where its floor was level with that of the hillside which he had j
left. In other words, his course, were it represented by a line, wo
outline the form of the hills and valleys or their contour. A se
of lines ("contours") drawn at given intervals above sea level
indicate very clearly, to one accustomed to the reading of conto
the form of the surface represented by them.



IS COUNTY, OKLA.

STRUCTURE.

Rock structure, as shown on the accompanying map (Pl. VI), has been worked out from a comparison of the logs of the several wells and from observations on an asphalt-bearing sandstone which outcrops at many places in the Loco field and which lies about 600 feet stratigraphically above the principal gas-bearing horizon. This asphaltic sandstone, or rather series of sandstones, for the different beds are separated by thin beds of shale, is about 20 feet thick, as is shown in the stratigraphic section given on page 34. At some places in the exposures it is possible to distinguish the relation of the particular bed on which observations are taken to the other beds in the series. The asphalt-bearing beds are thus a great aid in an accurate determination of the structure, for by calculating the altitude of the base of the series throughout the field, the nature of the rock folds becomes apparent. The asphalt-bearing sandstones in this area are so uniformly impregnated with asphalt as to make it seem probable that they represent former oil sands which have been brought to the surface by erosion, the petroleum in them being oxidized to asphalt.

The largest exposures of the bed of asphaltic sandstone lie in secs. 23, 24, 25, and 26, T. 3 S., R. 5 W., and outline in cross section an anticline the axis of which trends in a northwesterly direction. (See Pl. VI.) The crest of the dome in this vicinity lies in the middle of the SW. ¼ sec. 24, the base of the asphaltic sandstone layer here being at an altitude of 930 feet. From the crest the bed dips to the northeast and to the southwest. To the northeast it may be traced for a quarter of a mile, being well exposed in the SE. ¼ NW. ¼ sec. 24, where, however, the rock is entirely free from asphalt and consists of a hard, compact, dirty-white calcareous sandstone. This rock appears to be identical with certain thin beds that alternate with the asphaltic sandstone beds farther southwest. The base is at an altitude of 894 feet, showing a dip of 36 feet to the northeast between this exposure and the one above described. The bed northeast of this point appears to be practically horizontal for at least half a mile, as the base of what is believed to be the same bed exposed 1,300 feet west of the northeast corner of sec. 24 is at an altitude of 899 feet.

In the SE. ¼ sec. 18, T. 3 S., R. 4 W., are exposed two beds of asphalt-bearing sandstone, the stratigraphic distance between the bases of which is 40 feet. These two sandstone beds are believed to represent the asphalt-bearing sandstone together with the highest bed in the exposure on the wooded knoll at the crest of the dome in the SW. ¼ sec. 24, T. 3 S., R. 5 W. (See p. 33.) If this correlation is correct the lower bed in the SE. ¼ sec. 18, T. 3 S., R. 4 W., lies 41 feet higher than the same stratum a mile to the west, and in the NE. ¼ sec. 24 there is a shallow syncline, on each side of which are showings of asphalt. The axis of this syncline, as may be seen on Plate VI, plunges to the north.

Southwest of the crest of the anticline, in the SW. ¼ sec. 24, T. 3 S., R. 5 W., the asphalt-bearing stratum dips to the southwest. Its base is at an altitude of 913 feet in the NE. ¼ SE. ¼ sec. 23 and at 889 feet one-third of a mile farther west. In the SE. ¼ NW. ¼ sec. 26 the same stratum is at an altitude of 890 feet, or 40 feet lower than it is on the crest of the dome a mile to the northeast. The same bed is exposed in the NE. ¼ NW. ¼ sec. 25, T. 3 S., R. 5 W., at an altitude of 915 feet, and at the old asphalt works just south of the center of the section it lies at an altitude of 918 feet. It is reported that asphalt was struck in a well 48 feet in depth in the NE. ¼ NW. ¼ sec. 35, T. 3 S., R. 5 W. The altitude of the surface at this well is 865 feet. The shape of the crest of the fold is indicated in sec. 25, T. 3 S., R. 5 W., and sec. 30, T. 3 S., R. 4 W., by altitudes on the bed of sandstone already mentioned as lying about 40 feet above the asphalt-bearing bed. The base of a sandstone believed to represent this higher bed lies at an altitude of 978 feet in the NW. ¼ NW. ¼ sec. 30, T. 3 S., R. 4 W. In the SE. ¼ NE. ¼ sec. 25, T. 3 S., R. 5 W., it is at an altitude of 980 feet, the bed being therefore practically flat between the two places. From the latter point, however, the dip is to the southwest, the base of the bed lying at an altitude of 945 feet in the SE. ¼ SW. ¼ sec. 25, T. 3 S., R. 5 W. What is believed to be the same bed is exposed in the NW. ¼ NW. ¼ sec. 36, where its base is at an altitude of 936 feet.

The extension of the Loco anticline to the southeast is indicated at several places in the southwestern part of T. 3 S., R. 4 W., by the presence of the lower asphalt-bearing sandstone. In the NW. ¼ SE. ¼ sec. 31 the bed is exposed at an elevation of 920 feet above sea level. A few hundred feet northwest of this locality sulphur water was encountered in a dug well. In the SE. ¼ SW. ¼ of the same section water carrying the taste of petroleum was found in a well at a depth of 43 feet, or about 930 feet above sea level. The upper sandstone is here exposed at the surface, its base being at an altitude of 967 feet, and it is probable that the water in the well comes from the top of the lower or asphalt-bearing bed, which is about 21 feet thick. The base of this bed is therefore at an altitude of 909 feet at this locality. The water in the well belonging to E. A. Burton, in the SE. ¼ SE. ¼ sec. 30, T. 3 S., R. 4 W., is highly impregnated with asphalt, which coats the bucket in which the water is drawn. The altitude of the mouth of the well is 962 feet, and the well is reported to be 54 feet in depth, so that the asphalt-bearing sandstone probably lies at an altitude of about 908 feet. In the NW. ¼ NW. ¼ sec. 32, T. 3 S., R. 4 W., salt water was encountered in a well, and in the NE. ¼ NW. ¼ of the same section the asphalt-bearing sandstone outcrops at an altitude of 912 feet. Asphalt is reported in a well in the SE. ¼ NE. ¼ sec. 32, T. 3 S., R. 4 W., which is said to be 40 feet in depth. The altitude of the mouth of the well is 919 feet. A test well 2,100 feet in depth has been drilled in the SW. ¼ NE. ¼ sec. 32, on the Boles farm, which did not encounter oil or gas in paying quantity. Sulphur water is found in a well in the SE. ¼ SW. ¼ sec. 33, in the same township, and salt water is found in a well belonging to Julia Long in the NW. ¼ NE. ¼ sec. 3, T. 4 S., R. 4 W. There are no surface indications of asphalt or petroleum in this vicinity nor to the east as far as the wells in the SE. ¼ sec. 36, T. 3 S., R. 4 W., at the northwest end of the Healdton field. In the NW. ¼ NW. ¼ sec. 29, T. 3 S., R. 4 W., asphalt is reported in an old well, and in the SE. ¼ SW. ¼ sec. 21 of the same township the water in a well on the Sessum farm tastes slightly of petroleum. The well is reported to be 119 feet in depth, and the altitude of its mouth is 861 feet.

Northwest of the outcrops in secs. 23 and 24, T. 3 S., R. 5 W., above described, the lower or asphalt-bearing sandstone is exposed in the NW. ¼ SE. ¼ sec. 14 at an altitude of 898 feet. A mile southwest of this locality a sandstone which is believed to represent the highest bed exposed in the SW. ¼ sec. 24, T. 3 S., R. 5 W. (see section on p. 33), is exposed, its base being at an altitude of 908 feet. In the NE. ¼ NW. ¼ sec. 27 an asphalt seep known as the Tar Spring occurs in what is believed to be the lower or asphalt bed, the base of the asphalt stratum being at an altitude of 862 feet.

Along the stream valley in the NE. ¼ sec. 11 a bed of sandstone is exposed continuously for about half a mile. Altitudes taken at several places along the bed indicate a rather pronounced dip north-northeastward. In the N. ½ sec. 4, T. 3 S., R. 5 W., three different beds of sandstone are exposed, which have a pronounced dip to the northeast. Their relation to the beds thus far described could not be determined. Just north of the township line road, in the SE. ¼ SW. ¼ sec. 31, T. 2 S., R. 5 W., the lower or asphalt-bearing sandstone is exposed, the asphalt stratum being at an altitude of 955 feet. About 600 feet farther east the hill is capped by the upper sandstone, the base of which is at an altitude of 997 feet. The asphalt-bearing bed is exposed in the SW. ¼ SW. ¼ sec. 31, where it lies at an altitude of 936 feet. There is therefore in this locality a dip to the west of 19 feet in about one-third of a mile, and the anticlinal axis lies farther east, its crest being perhaps coincident with that of the wooded hill, part of which lies in the NE. ¼ sec. 6, T. 3 S., R. 5 W.

The structure in the vicinity of the gas wells has been worked out principally by means of the information afforded by the well logs, but as it is often difficult to make exact correlations between the logs of different wells conclusions based upon them must be taken as more or less conjectural. The gas wells in the NE. ¼ sec. 15, T. 3 S., R. 5 W., appear to be on the point of an anticline which extends in a northwest direction. North of the wells in the east part of section 10 there is a rather steep dip to the northeast (see Pl. VI), which is present also in the NE. ¼ sec. 11, T. 3 S., R. 5 W., as is shown by the exposures of a bed of sandstone at this locality. South of the wells in the south half of sec. 15 there is a dip to the southwest. Under these conditions the end of the anticline in the NE. ¼ sec. 15 constitutes a most favorable location for the accumulation of gas.

In the SW. ¼ sec. 24, T. 3 S., R. 5 W., there is a second end or "nose" of an anticline which might be tested by a well located at the south end of the small wooded knoll at this locality. The dips on the flanks of this fold are not, however, as steep as are those on the flank of the similar structure noted in sec. 15. If the well in the SE. ¼ SW. ¼ sec. 24 were successful the area to the south should be tested, particularly the NE. ¼ sec. 25, T. 3 S., R. 5 W., the southwestern part of sec. 30, T. 3 S., R. 4 W., and the northeastern part of sec. 31, T. 3 S., R. 4 W. The well of the Nippon Oil Co., in the NE. ¼ SE. ¼ sec. 26, T. 3 S., R. 5 W., is on the flank rather than on the crest of the anticline.

If the lower of the two asphaltic sandstone beds exposed in the SE. ¼ sec. 18, T. 3 S., R. 4 W., is the same as the bed exposed in secs. 24 and 25, T. 3 S., R. 5 W., it is evident that the strata are higher in this locality than they are farther to the west, and a test well might be drilled near the southeast corner of sec. 18, T. 3 S., R. 4 W.

The well drilled by the Oklahoma Diamond Oil & Gas Co. near the center of sec. 9, T. 3 S., R. 5 W., on the Ida Billy farm, obtained dark and rather heavy oil with a production as reported of 25 barrels. This well appears to be located on a broad structural terrace, and as far as our present knowledge goes most of the N. ½ sec. 9, with the exception of a small area near the northeast corner, should be territory as good as that on which the well is situated. Well No.1 of the Oklahoma Oil & Gas Co., in the SE. ¼ SW. ¼ sec. 6, T. 3 S., R. 5 W., obtained only showings of oil and gas. The location of the anticlinal axis in this locality is somewhat uncertain; it appears to lie about three-quarters of a mile northeast of well No. 1. A well drilled in the NE. ¼ NE. ¼ sec. 6, T. 3 S., R. 5 W., should prove a fair test of the locality.

The above suggestions in regard to prospecting the field are made after a careful consideration of all the data available. The reader should bear in mind, however, that rock outcrops in parts of this area are very few and that a slight error in correlation between beds in surface exposures or in well logs might change materially the apparent shape of the structure. If the information concerning the area is meager, the predictions in regard to the location of oil and gas pools in it must be either meager or more or less conjectural. The writer in his work has endeavored to go as far as possible in his predictions, trusting to his reader to interpret his remarks in the spirit in which they are written.

ORIGIN OF THE OIL AND GAS.

Oil and gas in the Loco field occur in small quantities in many of the Permian sandstone beds, but the principal gas-bearing zone consists of one or more beds of sandstone occurring within 250 feet of the base of the Permian at depths ranging in the various wells from 650 to 750 feet below the surface. In certain of the deeper wells showings of oil and gas have been obtained in the strata which underlie the Permian and which are probably Pennsylvanian in age. From the fact that in the great oil fields of northern Oklahoma the oil is obtained from beds of Pennsylvanian age, as well as from the nature of the sedimentary rocks themselves (the rocks of the Pennsylvanian containing more organic matter than do those of the Permian) it seems probable that the oil which is found in Permian beds is derived from the underlying older rocks. In the Loco field these rocks are shown to be of Carboniferous age by the crinoid stems and small pelecypods which have been obtained from the cuttings of wells Nos. 1 and 5 of the Oklahoma Diamond Oil & Gas Co. As the oil and gas appear to have accumulated in the Permian strata near the crests of folds, it is evident that the oil must have accumulated since the folding occurred. That the folding occurred in comparatively recent geologic time is indicated by the fact that along Red River southwest of the Loco field the smaller drainage shows a minute adjustment to the structure, which would not be the case had the folding taken place at a very remote period.[1]

Many theories have been advanced to account for the origin and accumulation of oil, but none have met with universal acceptance. To the writer it seems most probable that oil and gas have been derived from organic matter contained in shale or limestone which has been distilled under conditions of heat and pressure produced by earth movement. The oil may have been impelled through the rock pores to its place of accumulation by water under the forces of capillarity and gravity, or it may have migrated through the rocks in the form of gas which afterward condensed into oil.[2]

ANALYSES OF GAS FROM THE LOCO FIELD.

Samples of gas collected by the writer in the Loco field were sent for analysis to the Pittsburgh laboratory of the Bureau of Mines, from which the following results are reported:

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[1] Wegemann, C. H., Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, p. 34 1915.

[2] For a fuller discussion of this subject see Wegemann, C. H., and Heald, K. C., The Healdton oil field, Carter County, Okla., pp. 13-30 of this bulletin.

Analysis of gas from well No. 7, of the Oklahoma Diamond Oil & Gas Co., northwest corner of sec. 15, T. 3 S., R. 5 W.

[Analysis by G. A. Burrell; laboratory No. 5864.]

CO_2	0.2
CH_4	75.1
C_2H_6	8.5
N_2	16.2
	100.0

Specific gravity (air=1), 0.67.

Heating value at 0° C. and 760 millimeters pressure, 958 British thermal units.

Analysis of gas from well No. 5 of the Oklahoma Diamond Oil & Gas Co., NE. ¼ sec. 15, T. 3 S., R. 5 W.

[Analysis by G. A. Burrell; laboratory No. 5865.]

CO_2	0.0
CH_4	80.2
C_2H_6	11.1
N_2	8.7
	100.0

Specific gravity (air=1), 0.65.

Heating value at 0° C. and 760 millimeters pressure, 1,061 British thermal units.

THE DUNCAN GAS FIELD, STEPHENS COUNTY, OKLAHOMA.

By Carroll H. Wegemann.

INTRODUCTION.

The Duncan gas field, sometimes known as the Hope field, lies in Stephens County, Okla., near the post office of Cruce, about 10 miles northeast of the town of Duncan. (See Pl. VIII and fig. 3.)

The first well in the field was drilled about 1907, in the NW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and is reported to have obtained some gas and oil but was abandoned. The Skelly Drilling Co. a few years later drilled three gas wells in the E. ½ sec. 12, T. 1 N., R. 6 W., and two dry holes, one a few rods west of the center of the same section and another in the NW. ¼ sec. 7, T. 1 N., R. 5 W. It is understood that these wells have since been taken over by the Washita Gas & Fuel Co., which itself began drilling in the field on March 20, 1912. The company's first well, which was a "gasser," was drilled in the NW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W. The company has drilled one other gas well in the same quarter section and two dry holes, one in the SW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and one near the middle of sec. 1, T. 1 N., R. 6 W.

A dry hole was drilled by the Stephens County Oil & Development Co. in the SE. ¼ SW. ¼ sec. 20, T. 1 N., R. 5 W., and a dry hole has been drilled by another company in the SW. ¼ SE. ¼ sec. 30, T. 1 N., R. 5 W.

The principal flow of gas in the wells is obtained at about 850 feet, and the wells vary in production from 3,000,000 to almost 18,000,000 cubic feet a day. A pipe line has been laid from the field to Duncan and supplies that town with gas.

The present report has been prepared by the United States Geological Survey under a cooperative agreement with the Oklahoma Geological Survey, according to which each organization furnished a part of the funds necessary for the work.

The field work for the report was done in September, 1914, the writer being assisted by Mr. Ralph W. Howell, of whose careful work he desires to express his appreciation. Thanks are due to Mr. B. A. Barnes, a resident of Duncan, for much information in regard to the field; also to the Washita Gas & Fuel Co., the Stephens County Oil & Development Co., and Mr. W. G. Skelly, for logs of wells drilled in the field.

DRAINAGE AND TOPOGRAPHY.

The Duncan field lies just south of the divide between Wild Horse and Brush creeks, both of which are branches of Washita River. The relief in the field is not over 250 feet, the most prominent topographic feature being an escarpment formed by a bed of sandstone which partially encircles the field. The region is for the most part covered with post-oak timber.

STRATIGRAPHY.

The surface rocks in the Duncan field are red beds of Permian age. They consist of shale, sandstone, calcareous sandstone and shale conglomerate. The shale is red or bluish gray in color. The sandstone is predominantly white or buff but is in some places red. The cement of the sandstone is calcareous and in some beds the lime content increases in amount until the rock is a calcareous sandstone. At the bases of certain of the sandstone strata, or embedded in them, are thin beds of conglomerate, the pebbles of which consist of fragments of shale. The fragments are more or less angular and do not appear to have been transported far from their place of origin, being of the same material as the ordinary Permian shale.

The most important bed or group of beds in the Duncan field structurally and stratigraphically is a series of sandstones and interbedded shale about 40 feet in thickness, which forms an escarpment that partly encircles the field. The surface of the bed is in most places timber-covered, and the line of wooded hills produced by its outcrop is a conspicuous topographic feature. The individual beds of the group are variable in thickness and extent but the group as a whole covers a broad area and has been traced for about 60 miles from a point north of Foster, a small settlement 18 miles east of the Duncan field, to the north flank of the Wichita Mountains. The sandstone in the Duncan field is white, but that in part of the adjoining area is pink or red, and there are places where the change from pink to red may be observed in a single outcrop. This sandstone group forms the best horizon marker in the region and it is by means of it that a considerable part of the structure in the Duncan field has been determined.

Below the sandstone lies about 100 feet of shale containing near its middle one or more thin beds of white sandstone, which are inconspicuous in outcrop. The shale is underlain by beds of sandstone interstratified with shale, the whole being about 300 feet thick. Where the sandstone beds reach the surface they form rounded knolls or ridges, which, however, are inconspicuous as compared with the escarpment of the higher group of sandstone beds. Below the soft sandstone and shale beds or about 400 to 500 feet below the base of the escarpment-forming sandstone, is a group of beds in which sandstone predominates and which, where it reaches the surface, produces hills and ridges of considerable height. The soil formed by this group of sandstones supports a thick growth of post oak like that of the higher escarpment-forming sandstone.

The nature of the strata which underlie the Duncan field is shown by the logs of the gas wells, the deepest of which is in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W. In this well red, brown, and bluish shale alternate with thinner beds of white sandstone to a depth of 1,825 feet, but below this depth the shale is prevailingly blue. At 1,900 feet a 20-foot bed of limestone is recorded. From observations in adjacent fields, it is believed that the red color in this region is confined to the Permian and that thick beds of limestone are not found in that formation. It therefore seems probable that the unconformity between the Permian and the underlying Pennsylvanian lies in the well mentioned above, between the red shale and the limestone, probably at the base of the 25-foot bed of "yellow quicksand" recorded at 1,825 feet. As none of the other wells in the field reached this depth it is impossible to demonstrate the presence of the unconformity by a comparison of logs. Its presence can be shown, however, in the Healdton and Loco fields, and the unconformity may be observed in surface exposures along the west end of the Arbuckle Mountains. Here the unconformity between the Permian and the underlying Carboniferous is well exposed east of the town of Poolsville, where steeply dipping Paleozoic beds, ranging in age from Ordovician to Pennsylvanian, are overlain unconformably by flat-lying deposits of Permian age.

Fossils are comparatively rare in the Permian. About 25 miles southwest of the Duncan field, in Cotton County, the bones of primitive amphibians have been found, and fossil leaves of Permian age have been collected in the Healdton field and near Dixie and Poolsville, southeast of the Duncan field. In the field itself certain of the sandstone beds bear the marks of plant stems, but the impressions are so indistinct that the nature of the plants can not be determined. They are perhaps algæ. Some of the thin beds of calcareous sandstone contain also very much broken fragments of shells, among which bits of crinoid stem were recognized.

INTERPRETATION OF STRUCTURE CONTOURS.

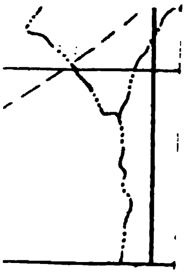
The structure contours shown on Plate VIII are drawn on the surface of the main gas sand (indicated on Pl. IX by correlation lines between plotted logs) and represent the slope of the folded surface of that bed. Every point along any given contour is at the same elevation above or below sea level, the lines being drawn at inte of 20 feet. To one unfamiliar with the interpretation of contour following somewhat fanciful conception may be of assistance.

Were it possible to remove all the overlying strata and to about on the surface of the oil sand, the course followed by one endeavored to walk always at an elevation of 200 feet abov level of the sea, never stepping up or down but walking al at the one level, would be that indicated by the 200-foot conto the map. When the pedestrian came to a knoll or jutting p he would be compelled, in order to keep at the same level, to around its side. When he reached the valley which lay betwee knoll and the next he would be obliged to walk up the valley point where its floor was level with that of the hillside that h just left. In other words, his course, were it represented by a would outline the form of the hills and valleys or their contou series of lines drawn at given intervals above sea level will repr very clearly to one accustomed to the reading of contours the fo the surface represented by them.

STRUCTURE.

The Duncan anticline proper is about 2 miles broad by 5 long, its axis trending a few degrees west of north. About 15 south by southeast of this fold, in line with its axis lies the Loc field, which is 10 miles northwest of the great Healdton field of C County. (See fig. 3.) Roughly speaking the three fields lie on a which partially encircles the west end of the Arbuckle Mount The mountains lie 25 miles east by south of the Duncan field. A 30 miles west of the Duncan field is the Lawton field, at the ea extremity of the Wichita Mountains, and between the Wichita Arbuckle uplifts there is a low arch, the north flank of which is lined by the escarpment which is so prominent in the Duncan This escarpment may be traced from a point in sec. 23, T. 2 R. 3 W., north of Foster post office, southwestward to and ar the Duncan gas field and thence to an exposure on the north si sec. 32, T. 1 N., R. 7 W., 1 mile north of the town of Duncan. F this place it may be traced northwestward in a straight line to NE. ¼ sec. 24, T. 4 N., R. 11 W., northeast of the Wichita Mount It doubtless extends farther northwest along the mountain fl The dips along this escarpment are comparatively low, not exc ing 1°, except in the vicinity of the Duncan field.

The southern limb of the low fold between the two mountain up can not be defined because of lack of exposures, and hence the e position of the axis of this fold is unknown. The cross fold w forms the Duncan anticline lies north of the axis, and the dome Loco and Healdton lie south of it. The three fields are in no s



along the axis of a continuous cross fold. They are in fact distinct structures but are so situated with reference to the Arbuckle uplift that they appear to have been originally formed at the same time by stresses acting between the rigid mass of the mountains and the strata of the plains. The Duncan field does not, however, like the fields south of the mountain axis, give evidence of two periods of folding. Its structure is more regular than that of the other oil or gas fields mentioned. As shown on Plate VIII, the axis lies midway between the sandstone escarpments on either side, and the beds dip from the axis at angles of about 3°. The anticline plunges rather steeply at its north end, and at its south end the escarpments formed by the outcropping edges of the sandstone beds diverge in a direction almost at right angles to the axis of the fold, the structure itself appearing to merge into that of the low arch above mentioned, connecting the two mountain uplifts. In the E. ½ sec. 6 and in sec. 5, T. 1 S., R. 5 W., a line of timbered hills is formed by the lowest group of sandstone beds exposed in the vicinity of the field. This line of hills may be traced southeastward to sec. 6, T. 2 S., R. 4 W., at which place grahamite deposits have been mined in the sandstone strata which form the ridge. As this ridge lies in approximate alignment with the axis of the Duncan fold, it may be to a certain extent anticlinal, although observations in the neighborhood of the grahamite mines, as well as in sec. 6, T. 1 S., R. 5 W., indicate that the beds in these two localities are horizontal. In sec. 32, T. 1 S., R. 4 W., about 1½ miles west of the town of Alma, sandstone beds exposed in a gulch north of the road appear to dip northward with the grade of the stream. This dip may in fact be to the northeast, away from the possible anticlinal axis on which the grahamite mines are situated. Because of the lack of definite beds which can be traced from place to place in this region, the exact nature of the structure is very difficult to determine.

OIL AND GAS.

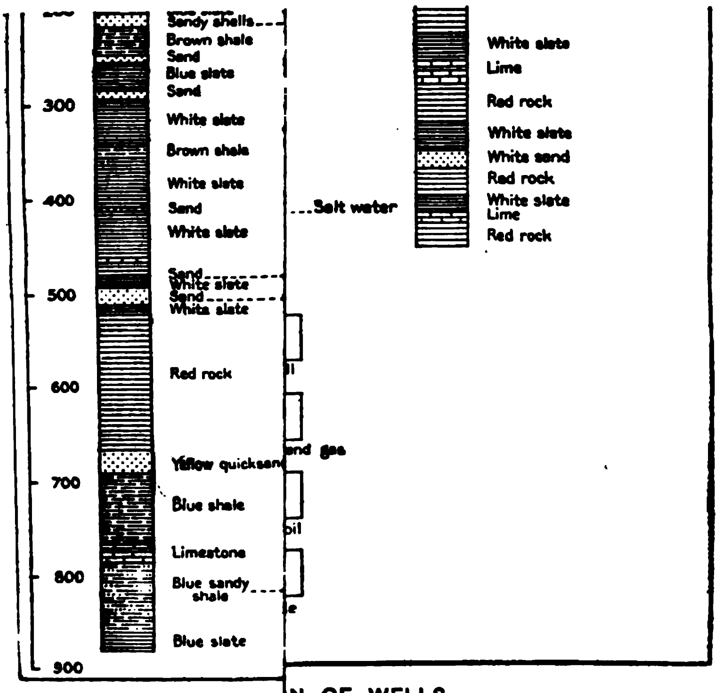
The principal gas horizon in the Duncan field, a sand from 7 to 19 feet thick, lies at a depth of 800 to 900 feet below the surface and about 900 feet above the base of the Permian as the formation is here developed. Showings of gas and heavy oil in small quantity are obtained in some of the wells in shallower sands, and it is reported that the gas sand on the limbs of the anticline below the gas pool in one well (in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W.) carries heavy oil in small amount.

None of the wells in the productive area in the Duncan pool extend far below the principal gas horizon, and hence the sands in the 900 feet of Permian beds which underlie this horizon have not been tested in the best part of the field. The deep well already mentioned, in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W., encountered showings of gas at a depth of 1,300 feet and a "rainbow" of oil at 1,625 feet, but whether or not these two beds would be productive on the crest of the anticline it is impossible to say in advance of drilling.

From a comparison of well logs as well as from studies of the surface rocks in the Duncan, Lawton, Loco, and Healdton fields, the following tentative correlations of the oil and gas sands may be made: The principal gas sand at Duncan is probably the same as the "400-foot sand" in the Lawton field, in which case the sand with showings of gas struck at 1,335 feet in the deep test well in the NW. ¼ sec. 12, T. 1 N., R. 6 W., of the Duncan field is the probable equivalent of the "800-foot sand" in the Lawton field. The gas sands at Loco probably lie at or a little above the same horizon, and the productive sands of Healdton some 300 or 400 feet lower, corresponding in a general way to the sand carrying showings of oil which was struck in the deep well at Duncan at 1,625 feet.

The extent of the gas pool to the southeast and the possible presence of oil in commercial quantity in the Duncan field are subjects on which no positive statements can be made. It appears probable that the axis of the anticline for at least a mile southeast of the gas wells should prove good gas territory. The well of the Stephens County Oil & Development Co. in the SW. ¼ sec. 20, T. 1 N., R. 5 W., was drilled too far east to test the possibilities of the anticline in this locality. The dry hole, however, in the SE. ¼ sec. 30, T. 1 N., R. 5 W., is in a good location. Its log was not obtained, but if it reached a depth of 1,000 feet without encountering oil or gas in commercial quantity it is probable that the anticline is barren in this part of the field, at least as regards the sands now producing in the Duncan field.

As the sandstones exposed in sec. 5 and the E. ½ sec. 6, T. 1 S., R. 5 W., are lower than any of the beds exposed in the vicinity of the gas wells, it is evident that the gas sand must be nearer the surface and hence the structure higher in secs. 5 and 6, T. 1 S., R. 5 W., than farther to the north. The dips in this locality are, however, very small, and so little is known of the exact shape of the fold that it is impossible to make predictions in regard to it. The well in NW. ¼ sec. 10, T. 1 S., R. 5 W., appears to have been drilled too far east to have been a fair test. The plunging end of an anticline like that on which the gas wells are situated is always a very favorable place for the accumulation of oil or gas, but it may be questioned whether in the more gentle folds, such as the fold which appears to be indicated by the sandstone ridge above mentioned in secs. 5 and 6, T. 1 S., R. 5 W., oil or gas are as likely to accumulate, even if the beds on the crest of the fold are in reality higher than those on the point of the anticline.


Sandy shells
Brown shale
Sand
Blue slate
Sand
300
White slate
Brown shale
White slate
400
Sand
White slate
Sand
White slate
500
Sand
White slate
Red rock
600
Yellow quicksan
700
Blue shale
Limestone
800
Blue sandy shale
Blue slate
900
Salt water
l
and gas
oil
e
White slate
Lime
Red rock
White slate
White sand
Red rock
White slate
Lime
Red rock

N OF WELLS.

Prospecting for gas in the Duncan field should be carried on along the crest of the anticline as indicated on Plate VIII, the first well being placed about half a mile south of the present productive wells. If the first well is successful other wells may be drilled at intervals of about half a mile along the axis to the southeast until the limit of the pool in this direction is reached.

The gas probably extends also about half a mile northwestward along the axis from the present productive wells.

The chances for obtaining oil in large quantity in the immediate vicinity of the gas wells would appear to be poor, inasmuch as the deep well in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W., was unproductive. Oil may possibly be found beyond the limits of the gas pool to the southeast along the anticlinal axis as indicated on Plate VIII, but this possibility can be tested only by systematic exploration of the gas pool in that direction as indicated above.

As the gas-bearing sand now known in the Duncan field lies 900 feet above the base of the Permian, and as lower Permian sands produce oil and gas in neighboring fields, the field can not be considered as thoroughly tested until the base of the Permian on the crest of the anticline is reached by the drill. The approximate depth to the base of the Permian at any given point, the elevation of the surface being known, may be estimated from the structure contour lines given on Plate VIII as follows: If at any given point the elevation of the surface is 1,100 feet and the elevation of the gas sand as indicated by the contours on Plate VIII is 280 feet, the gas sand is 1,100 feet minus 280 feet, or 820 feet below the surface. As the base of the Permian is about 900 feet below the gas sand, it is 820 feet plus 700 feet, or 1,720 feet below the surface at the given point.

If the Permian sands below the gas sand be found unproductive in the most favorable part of the Duncan anticline—that is, in the vicinity of the wells already drilled or just southeast of them—they will probably be barren in other parts of the field. If, however, they are found to carry oil or gas in paying quantity test wells in other parts of the field should reach them.

COMPOSITION OF GAS IN THE DUNCAN FIELD.

Below is a report of an analysis made by the Bureau of Mines of a sample of gas, collected in the Duncan field by the author of this report.

The sample was taken September 25, 1914, from a well drilled by W. G. Skelly in the NE. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W.

Analysis of gas from the Duncan field, Oklahoma.

[Laboratory No. 5862.]

CO_2	0.4
CH_4	91.9
C_2H_6	4.1
N_2	3.6
Total	100.0

Specific gravity (air=1), 0.59.
Heating value at 0° C. and 760 millimeters pressure, 1,055 British thermal units.

A RECONNAISSANCE IN PALO PINTO COUNTY, TEXAS, WITH SPECIAL REFERENCE TO OIL AND GAS.

By CARROLL H. WEGEMANN.

INTRODUCTION.

The presence of oil and gas in Palo Pinto County, Tex., has been known for a number of years. Wells drilled for water at Mineral Wells, on the east border of the county, encountered "showings" of oil and gas. Several gas seeps were known to ranchers north of Palo Pinto, in the central part of the county, and a small gas field was discovered several years ago on lands held by the Texas & Pacific Coal Co., near the towns of Strawn and Thurber, in the southwestern part.

The reconnaissance here reported was undertaken by the United States Geological Survey in the fall of 1914, in order to determine whether anticlines which might have influenced the accumulation of oil were present in the region and to point out, if possible, areas in which drilling might be successful.

The author was assisted both in the field and in the office by Mr. Ralph W. Howell, of whose careful work he desires to express his appreciation. Thanks are due to many residents of the district who have supplied valuable information.

In the time available for the work it was impossible to make an examination of the whole county, and therefore an area was chosen in which, from the nature of the outcrops and the character of the country, geologic work could be carried on most rapidly and in which also there were indications of gas. This area (see fig. 4) lies in the north-central part of the county and includes the prominent escarpment that trends northeastward about 4 miles northwest of the town of Palo Pinto. This escarpment is capped by thick beds of limestone, and a well-known point along it is a high butte south of Brazos River known as Kyle Mountain. The group of limestone beds constitutes stratigraphically and structurally one of the best horizon markers in the field.

HISTORY OF DEVELOPMENT AND DESCRIPTION OF GAS SEEPS.

At the time of the examination the only important oil or gas development in the region was that of the small gas field southwest of Strawn, in the extreme southwestern part of the county. This field had been developed by the Texas & Pacific Coal Co., operating at Thurber, and contained nine or ten gas wells ranging in capacity from 273,000 to a little over 2,000,000 cubic feet a day. The daily production of the entire field was estimated at about 8,700,000 cubic feet. The gas was obtained at about 400 to 600 feet below the surface, the depth depending on the position of the well with reference to a small local dome which appears to have controlled the accumulation.

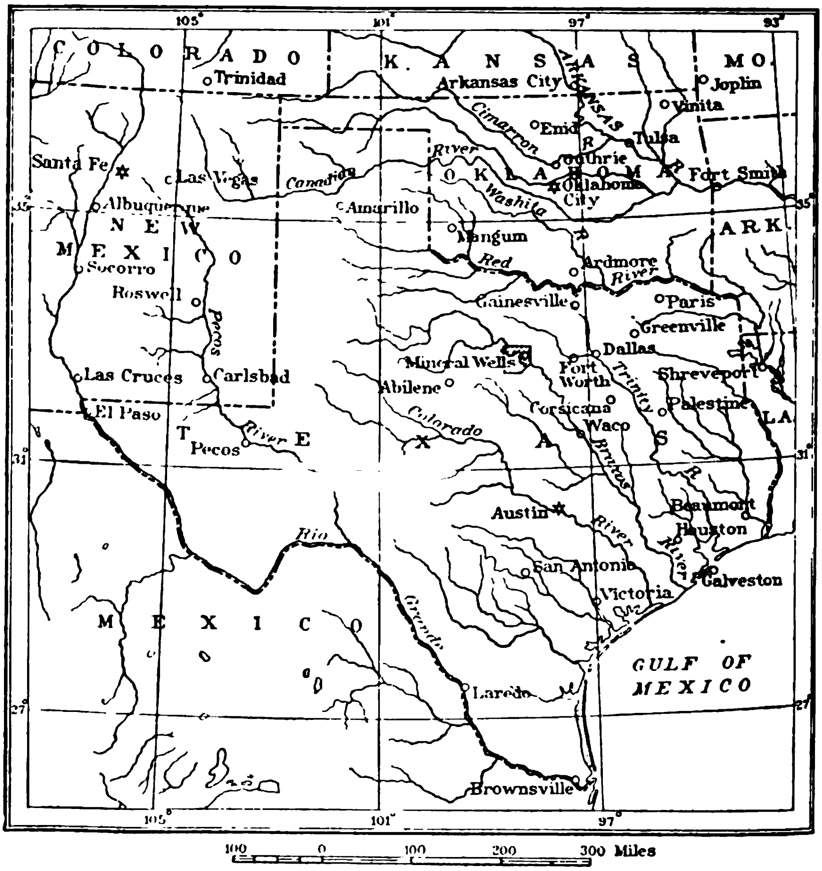


FIGURE 4.—Index map of Texas showing area examined in Palo Pinto County.

Since this examination was made an oil field has been discovered about 3 miles northwest of the gas field and northwest of the town of Strawn, and drilling is being actively carried on, not only in the vicinity of the new field but throughout the area.

In the town of Mineral Wells, at the east side of the county, small showings of oil have been encountered at a depth of about 100 feet in wells drilled for mineral water. The strata here dip at a low angle to the northwest, and on the W. W. Johnson place, 1¾ miles north of the town, a small amount of heavy oil was encountered in this same sand at a depth of 350 feet. About 1½ miles northwest of the town, in the Crenshaw well, several gallons of oil was encountered at a depth of 520 feet, in a sand about 300 feet below that which carries the mineral water at Mineral Wells.

In the north-central part of Palo Pinto County a gas seep occurs about a mile northwest of Kyle Mountain and half a mile east of Brazos River. Gas bubbles here rise in a pool of water in the bed of a small tributary of the Brazos. The bottom of the pool is limestone. On the Dalton ranch, about a quarter of a mile northeast of this gas seep, a well has been drilled which is said to have encountered a small flow of gas at 385 feet below the surface and a greater flow at 854 feet. It is reported that this gas, being lighted at the mouth of the casing, burned for almost a year. No odor of gas could be detected in this old well at the time of the writer's examination. Within a few rods of this well another test hole is at present being drilled by the Crazy Oil & Gas Co.

About 3 miles north and a little east of the last-named locality, on the west bank of Dark Valley Creek, 1 mile north of Brazos River, is a well which is said to have obtained a good showing of gas. The casing was open at the time of the examination and the odor of gasoline could be detected. A lighted paper dropped into the casing produced an explosion. Bubbles of gas were observed rising in the mud and water at the mouth of Dark Valley Creek, but the nature of the gas was not determined.

TOPOGRAPHY.

The region is one of considerable relief, some of the hills rising to heights of 500 feet above the valley floors. The ruggedness of the surface is produced by a series of escarpments which trend in a northeasterly direction and are formed by the outcropping edges of sandstone and limestone beds that dip at low angles to the northwest. The most prominent of these escarpments, about 200 feet above the adjacent plain, is that formed by the group of limestone beds which caps Kyle Mountain. Northwest of this escarpment the country is very rough and in part is heavily timbered. East of the escarpment is a belt of comparatively open country about 5 miles in width, the surface of which, formed by a limestone bed lower than that which caps Kyle Mountain, is covered only by a growth of mesquite. The eroded edge of this lower limestone bed forms the crest of another escarpment, southeast of which are a series of timber-covered escarpments formed by sandstone strata.

The county is crossed from northwest to southeast by Brazos River, which flows in wide intrenched meanders, suggesting that its course was chosen when it flowed on a low-lying and featureless plain, which has since been uplifted and eroded. The present stream valley is comparatively narrow and is bordered by high bluffs.

STRATIGRAPHY.

Palo Pinto County lies on the east side of the Carboniferous area which in Texas extends from Red River on the north to San Saba, McCulloch, and Concho counties on the south and in its widest part from Parker County on the east to Jones County on the west. Throughout most of this area the strata have a prevailing dip to the northwest. On the east the Carboniferous rocks are covered by Cretaceous deposits, which overlie them unconformably. On the west the Cisco, which is regarded as the uppermost formation of the Pennsylvanian, is overlain by the Permian "Red Beds."

In Palo Pinto County only two formations are exposed at the surface, both of which are of Pennsylvanian age but older than the Cisco, which is not present in the county. The older of these formations, the Strawn, is about 1,700 feet thick,[1] and the younger formation, the Canyon, about 750 feet thick. In the Strawn formation are included the Strawn and Millsap formations as originally named by Cummins,[2] who, however, later modified his definition of the Strawn to include the "Millsap."

The base of the Strawn formation is not exposed in this region, being covered by the Cretaceous deposits on the east. The formation consists mainly of alternating beds of dark shale, gray shale, sandstone, and conglomerate but includes several thin beds of limestone. Its upper limit is placed, according to Cummins, at the base of the heavy beds of limestone of the formation above. About 700 feet below the top of the Strawn formation is the coal bed mined at Thurber, Gordon, and Strawn, and formerly mined 4 miles east of Mineral Wells.

The Canyon formation overlies the Strawn and consists of thick beds of limestone, sandstone, and gray shale. To quote from Cummins: "This division is characterized by the heavy beds of limestone found in it and is easily recognized by this fact, the limestones in other divisions being much thinner bedded." He states also that limestones of this formation may be observed at Palo Pinto. This town is built on a limestone bed which is about 400 feet below that capping Kyle Mountain and which forms the escarpment crossed by the Mineral Wells road, 2 miles east of Palo Pinto. As there is no lower limestone bed of prominence exposed in this area, it is probable that the rock on which Palo Pinto is built was considered by Cummins as the basal bed of the Canyon formation, and it is so represented on the accompanying map (fig. 5, p. 56).

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[1] Gordon, G. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, p. 15, 1913.

[2] Cummins, W. F., Report on the geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., p. 374, 1890.

Of the several escarpments which cross Palo Pinto County from northeast to southwest and are formed by the outcropping edges of sandstone and limestone strata, three are particularly prominent—the one just described, formed by the basal limestone of the Canyon formation; a second, of which Kyle and Wolf mountains are a part and which is formed by a limestone bed 400 feet above the base of the Canyon formation; and a third, which lies north of the Texas & Pacific Railroad, between Brazos and Gordon, and is formed by a sandstone of the Strawn formation, a little above the Thurber coal bed. In tracing these three escarpments from northeast to southwest across the county they appear to converge, as if the dip of the rock strata increased slightly in that direction.

METHODS OF FIELD WORK.

Geologic observations to determine structure were confined in the present examination to the limestone bed which forms the second of the escarpments just mentioned and which is well exposed in Kyle Mountain, north of Palo Pinto. By a system of plane-table triangulation, together with vertical angles read with a telescopic alidade, numerous elevations were taken on the top of this limestone bed at intervals along the escarpment for a distance of 16 miles. From these observations it has been possible to make a structure-contour map of the surface of this limestone, showing the shape of the folds into which it has been thrown and the relations of these folds to the gas seeps and gas wells in the region.

INTERPRETATION OF STRUCTURE CONTOURS.

The structure contours given in figure 5 are drawn upon the surface of the 50-foot limestone bed and represent the folded surface of that bed as it was before parts of it were removed by the action of streams. Every point along any one contour line is at the same elevation above or below sea level, and the lines are drawn to show differences of 20 feet in elevation.

To one unfamiliar with the interpretation of structure contours the following somewhat fanciful conception may be of assistance. Were it possible to remove all the overlying strata and to walk about on the upper surface of the limestone bed the course followed by one who endeavored to walk always at an elevation of, say, 1,200 feet above the sea, never stepping up or down, would be that indicated by the 1,200-foot contour on the map. When the pedestrian

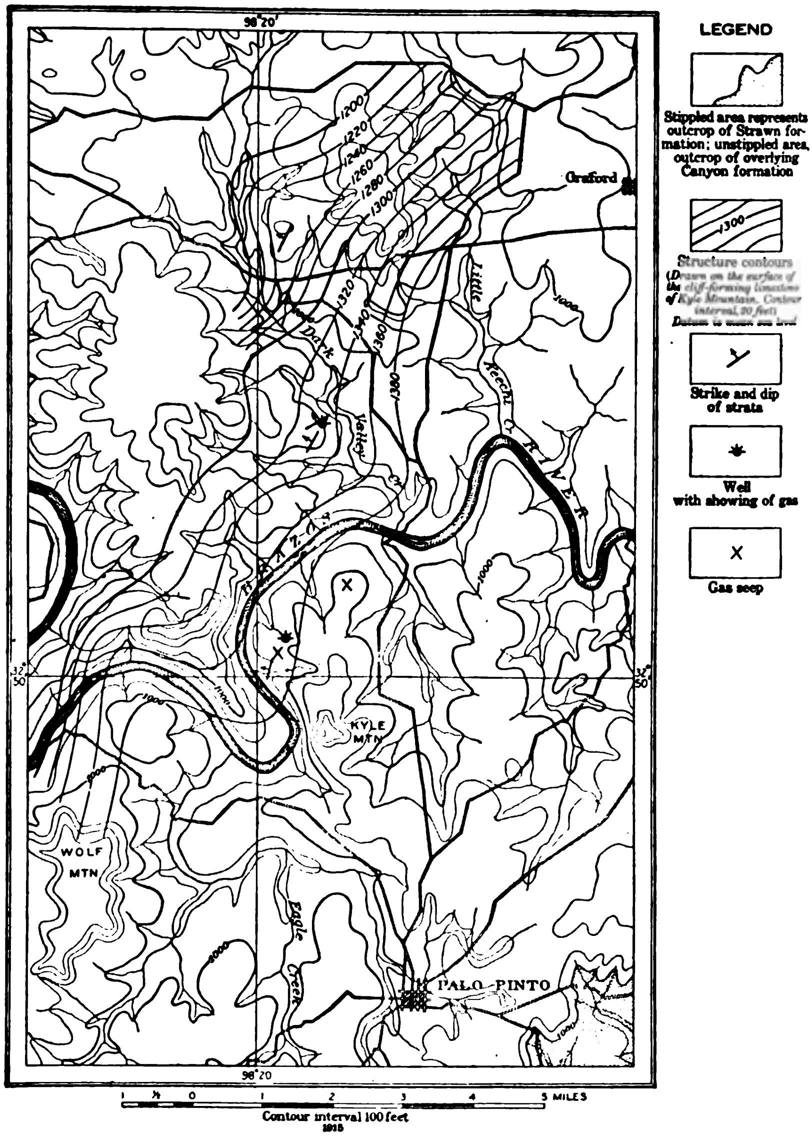
98°20'
1200
1220
1240
1260
1280
1300
1320
1340
1360
1380
1000
Graford
Little
Keechi Cr.
Dark
Valley
Brazos River
T. & P. R. R.
Kyle Mtn
Wolf Mtn
Eagle Creek
Palo Pinto
32° 50'
98°20
1 ½ 0 1 2 3 4 5 MILES
Contour interval 100 feet
1915
LEGEND
Stippled area represents outcrop of Strawn formation; unstippled area, outcrop of overlying Canyon formation
1300
Structure contours (Drawn on the surface of the cliff-forming limestone of Kyle Mountain. Contour interval 20 feet) Datum is mean sea level
Strike and dip of strata
Well with showing of gas
X
Gas seep

FIGURE 5.—Map of anticlinal structure north of Palo Pinto, Tex.

came to a knoll or jutting point he would be compelled, if he did not wish to ascend, to walk around its side. When he crossed the valley that lay between this knoll and the next he would be compelled, if he did not wish to descend, to walk up the valley to a point where its floor was level with that of the hillside which he had just left. His course, in other words, were it represented by a line, would represent the form of the hills and valleys or their contour. A series of lines drawn at regular intervals above sea level will indicate very clearly, to one accustomed to the reading of contours, the form of the surface represented by them.

STRUCTURE.

The dominant structure in north-central Texas west of the Cretaceous area is a monocline in which the beds dip toward the northwest at the rate of about 40 or 50 feet to the mile. Superimposed upon this monocline there are, in certain localities, small cross folds, the axes of which trend in a northwesterly direction, at right angles to the prevailing strike of the rocks. It is these cross folds which appear to have been the chief factors in determining the places of accumulation of oil and gas. The broadest cross fold in the part of Palo Pinto County which was examined in greatest detail in the present work lies in the vicinity of Kyle Mountain, 4 miles north of the town of Palo Pinto. Kyle Mountain is about 2 miles southeast of the main line of the escarpment, and the limestone bed which caps it is evidently the same as that forming the escarpment. There is, however, a difference of only about 50 feet in altitude between the thick limestone bed on Kyle Mountain and that of the main escarpment, whereas if the normal dip prevailed at this locality, the bed on Kyle Mountain should be at least 100 feet above that on the escarpment. There is at this locality, therefore, a change of dip such as is found in many places near the axes of cross folds. The presence of a cross fold is demonstrated also by other observations taken along the line of the escarpment.

The gas seep on the Dalton ranch, 1 mile northwest of Kyle Mountain, is a little south of the axis of this fold, which extends in a northwesterly direction. (See fig. 5.) The old well on Dark Valley Creek 1 mile above its mouth is near the axis of the syncline, on the opposite side of the fold. From dip and strike readings taken on the limestone bed exposed near the old well there appears to be at this locality a small local roll which may account for the gas found in the well. The prominent hill 4 miles due north of the bridge over Brazos River and 4 miles west and a little south of Graford appears to be near the axis of another and smaller anticline. The beds at the southeast end of this hill dip to the northwest, but

2 miles farther west the strike changes until the beds dip to the west, as if this anticline were separated from that of Kyle Mountain by a shallow syncline whose axis lies in the vicinity of Dark Valley Creek. (See fig. 5.) In Wolf Mountain the strike of the beds appears to be approximately north, a fold northeast of Wolf Mountain being separated from the Kyle Mountain fold by a shallow syncline. How far the Kyle Mountain fold extends toward the southeast has not been determined, but it is probable that a minor fold of this nature would not extend for any great distance.

Details of structure were not worked out in other parts of the area. The gas wells in the Thurber field, 3 miles southwest of Strawn, appear to be on a small dome or anticline, as is shown by a comparison of the logs of the wells.

A thin bed of limestone half a mile west of Brazos strikes N. 72° E. and dips toward the northwest at low angles. At Mineral Wells the strike of the beds is N. 41° E., and on Brazos River between Mineral Wells and Palo Pinto it is N. 61° E. Northwest of Santo a broad semicircular valley about 3 miles wide is bordered by steep escarpments capped by a thick bed of sandstone. From a brief inspection of this locality the beds appear to be very nearly horizontal.

OIL AND GAS.

Gas was encountered in the well on the Dalton ranch, 1½ miles northwest of Kyle Mountain, at depths of 385 and 854 feet. The limestone bed which forms the surface at the Dalton well appears to be that which caps a prominent escarpment a little west of the Thurber gas field, and from a study of the well logs in that field it seems probable that the gas is derived from the same sand as that which was encountered at 840 feet in the Dalton well. This sand lies about 140 feet below the Thurber coal. The oil reported from the Crenshaw well, about 1½ miles northwest of the town of Mineral Wells, appears to have been derived from beds at this same horizon. The mineral water and "showings" of oil at Mineral Wells are obtained from a sand about 300 feet above the Thurber gas sand.

The Dalton well is on the flank of the anticline north of Kyle Mountain, and as it did not obtain oil or gas in commercial quantity from the Thurber gas sand or from any higher bed, it is probable that if oil or gas are to be found in commercial quantity in the Kyle Mountain anticline they must be sought in deeper sands. It is reported in the trade journals that the new oil field northwest of Strawn obtains its oil from a sand lower than that producing gas in the field west of Thurber. If this report is correct, there is a chance of obtaining either oil or gas in the equivalent of this sand in the Kyle Mountain anticline. This anticline is now being tested by a well being drilled close to the old Dalton well. If gas should be encountered in this test well, oil is probably to be sought down the dip to the northwest and gas up the dip to the southeast. If oil should be encountered in the test well, future drilling should be done either northwest or southeast of the first well along the axis of the anticline, but the wells should not be placed very far apart, as the extent of the anticlinal structure in these directions is unknown. If the well should prove to be a dry hole, it is probably useless to expect that the sands tested by it will be found productive in other parts of the Kyle Mountain anticline.

A fold similar to the Kyle Mountain anticline but less extensive appears to lie about 4 miles north of the Brazos River bridge on the Palo Pinto-Graford road. This fold, though presumably not so favorable to oil accumulation as the Kyle Mountain anticline, may contain deposits of oil or gas and should be tested by a well southwest of the southeast extremity of the high bluff or mountain which lies north of its axis. (See fig. 5.) Another anticlinal fold occurs between Kyle and Wolf mountains.

The probabilities are somewhat against the finding of oil or gas in the synclines which lie northeast and southwest of the Kyle Mountain anticline.

WATER SUPPLY AT MINERAL WELLS.

The possibility of finding soft water near Mineral Wells at greater depths than any yet reached by the wells in that town is a question of considerable local interest, and although it has no bearing on the occurrence of oil it may not be out of place to discuss it here.

Soft water of good quality is now obtained from a sand about 50 feet below that which carries the "mineral water." This soft-water sand apparently lies about 70 feet above the Thurber coal. At Thurber several deep wells have been drilled by the Texas & Pacific Coal Co., but in none of them was good water obtained in beds below the coal. Numerous sands were encountered, but the water contained in them was either salty or charged with "alkalies." Considering these facts, the chances of obtaining a good water supply at Mineral Wells by deep drilling into the beds tested at Thurber appear to be poor.

POSSIBILITIES OF OIL IN THE PORCUPINE DOME, ROSEBUD COUNTY, MONTANA.

By C. F. Bowen.

INTRODUCTION.

Requests for information concerning possible occurrences of oil and gas in Montana are frequently received by the Geological Survey. Partly to meet this demand for information, partly because the area described has attracted more or less local attention as a possible oil field, and finally, to place before the public information concerning the log of the deep well drilled for water at Vananda, on the Chicago, Milwaukee & St. Paul Railway, this paper has been prepared.

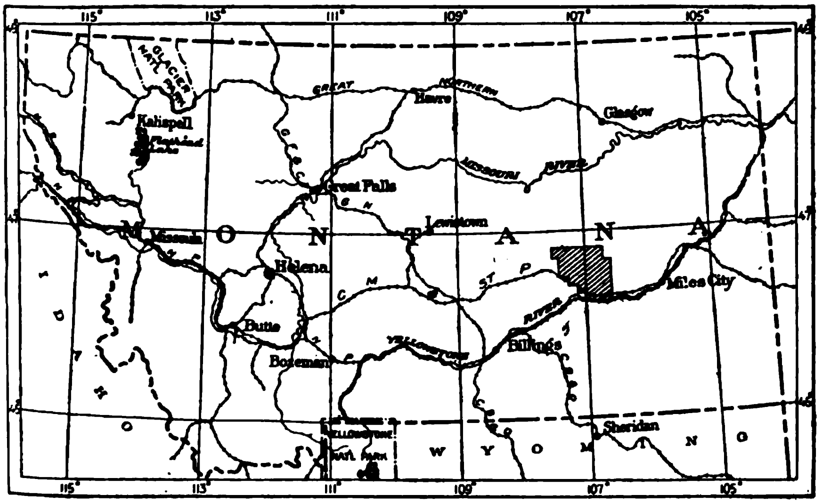

FIGURE 6.—Index map of Montana showing location of the Porcupine dome.

The examination has demonstrated the existence of structural and stratigraphic conditions suitable for the accumulation of oil and gas if these substances were originally contained in the strata, but it has not proved their existence in the area examined. In fact, there are no known surface indications of oil or gas in this area, and no well other than the water well mentioned above has been drilled to determine whether or not they occur below the surface.

In the following pages it is proposed to describe the stratigraphy and structure of the area, to point out some of the more commonly recognized principles controlling accumulations of oil and gas, and to apply these principles so far as practicable to the area under consideration.

The Porcupine dome lies north of Forsyth, east of the Chicago, Milwaukee & St. Paul Railway, and is included in the drainage basin of Porcupine and Little Porcupine creeks. It includes Tps. 7 to 12 N., Rs. 36 to 40 E. of the principal meridian, Montana. (See fig. 6.)

BASIS OF REPORT AND MAP.

The information here presented regarding this field was obtained by C. A. Bonine and the writer in the summer of 1914 while making a reconnaissance survey of an area lying principally to the north and northwest of the Porcupine dome. In the prosecution of that work the eastern and northern margins of the dome were examined and mapped in more or less detail. Information concerning the remainder of the area is based on two hasty reconnaissance trips across it during the progress of the work.

The accompanying map (Pl. X) has been compiled from township plats of the General Land Office, from the writer's field sheets, and from such information as was obtained in the reconnaissance trips referred to above. Because of the lack of detailed knowledge of the southern and western parts of the area the geologic boundaries and structure of these parts can not be accurately depicted and no attempt has been made to do more than outline roughly the area of the dome and show its general structure. These representations are merely approximations and will be modified as to details by future careful work, but it is believed that the general features are in the main correct. In the eastern and northern parts of the field, where more detailed work was done, the formations, except the Colorado and Claggett, are differentiated and their boundaries accurately located.

GEOLOGY.

SEDIMENTARY ROCKS.

GENERAL SECTION.

The formations exposed at the surface in this area extend from the Lance formation down to the upper part of the Colorado shale, inclusive. A deep well put down at Vananda by the Chicago, Milwaukee & St. Paul Railway Co., in an attempt to obtain an adequate supply of water for railway and domestic use, is believed to have penetrated the underlying rocks down to the Kootenai or some related formation. Through the courtesy of the railway company the writer is permitted to publish the record of this well, and it is therefore possible to present a section of the formations represented in this part of Montana extending from the Lance down to the upper part of the Kootenai (?). These formations include in ascending order the Kootenai (?), Colorado, Claggett, Judith River, Bearpaw, and Lance. The sequence, character, and thickness of these formations are shown in the geologic table and well record given below.

One noteworthy fact brought out by the well record and by the areal mapping of the surface formations is the absence of the Eagle sandstone, which forms so conspicuous a unit at the base of the Montana group farther west. The writer was able to determine within very narrow limits the easternmost point at which the Eagle can be recognized, and can positively assert that it is not present as a mappable unit east of Musselshell River.

Geologic formations exposed in the Porcupine dome, Montana.

System.	Group.	Formation.	Thickness. *Feet.*	Character.
Quaternary.				Alluvial gravel, sand, and silt along Yellowstone and Musselshell rivers and some of the smaller streams.
Tertiary (?).		Lance formation.		Brown, irregularly bedded sandstone, alternating with "somber" gray shale.
Cretaceous.	Montana.	Bearpaw shale.	900-1,100±	Dark-gray shale in which occur calcareous concretions containing marine invertebrate fossils.
		Judith River formation.	100-200±	Upper sandstone member, light-brown to light-gray massive sandstone. Middle member, light-gray to dark-gray shale. Lower member, sandstone, which weathers brown and gives rise to large bowlderlike masses. The formation is of fresh-water origin in the western part of the field and of marine origin in the eastern part.
		Claggett and Colorado shales.	3,000	Dark-gray to black shale; upper part highly plastic when wet and contains fossils characteristic of the Claggett formation; lower part slightly darker in color, more fissile and less plastic when wet, and contains fossils of Colorado age.

Log of well drilled by the Chicago, Milwaukee & St. Paul Railway Co. at Vananda, in sec. 5, T. 7 N., R. 38 E., Montana, between October 23, 1913, and October 17, 1914.

[Elevation of mouth of well, 2,704 feet above sea level.]

Formation.[a]	Driller's description.		Thickness.	Depth.
			Feet.	*Feet.*
Judith River formation.[b]	Shale, sandy		23	23
	Sand; 30 gallons of water an hour		7	30
	Shale, yellow		16	46
	Sand		11	57
	Shale and sand		24	81
	Sand		8	89
	Shale, yellow		16	105
	Sand		14	119
	Sand and shale		24	143
	Shale, blue		46	189
	Sand; flow of alkaline water, 2,400 gallons an hour		26	215
Claggett shale.[c]	Shale; disintegrates when exposed to air		685	900
(d)				
Colorado shale.	Shale,[e] black surface; whitens on exposure to air		140	1,040
	Shale		907	1,947
	Oyster-shell rim, fossil determined by former State geologist of South Dakota as *Inoceramus labiatus.*		5	1,952
	Shale, dark brown		107	2,059
	Hard rock		29	2,088
	Shale, soft; color changes on exposure from dark to light brown.		32	2,120
	Shale, light brown		40	2,160
	Slate		40	2,200
	Soapstone		13	2,213
	Shale, white		23	2,236
	Shale, dark		45	2,281
	Shale, black		19	2,300
	Shale, brown		100	2,400
	Shale, dark, caving		31	2,431
	Slate, caving		19	2,450
	Limestone		41	2,491
	Shale		239	2,730
	Shale and lime shells		15	2,745
	Shale, soft, caving		35	2,780
	Shale and lime shells		20	2,800
	Shale, soft, caving		105	2,905
	Shale, dark		35	2,940
	Shale and lime shells		103	3,043
	Sandstone, hard	May represent the Mowry shale member.	32	3,075
	Limestone, black, sandy		18	3,093
	Limestone		42	3,135
	Slate		55	3,190
Kootenai (?).	Sand, water bearing; water rose within 50 feet of surface.		10	3,200
	Sandstone, compact		30	3,230
	Limestone		19	3,249
	Shale, white		23	3,272
	Shale, red		7	3,279
	Shale, white		8	3,287
	Shale, red		27	3,314
	Shale, white		8	3,322
	Shale, red		35	3,357

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[a] Correlation revised by author.
[b] Called Lance in log furnished by railway company.
[c] Called Pierre in log furnished by railway company.
[d] In view of the lithologic similarity between the Claggett and Colorado the position of this boundary must be regarded as uncertain.
[e] Called Niobrara in log furnished by railway company.

KOOTENAI (?) FORMATION.

The Kootenai (?) formation, according to the writer's interpretation of the Vananda well record, was encountered at a depth of 3,200 feet and was penetrated by the drill to a depth of 157 feet.

This part of the formation consists mainly of alternate layers of red and white shale, overlain by a thin bed of limestone, and this in turn by a bed of sandstone 40 feet thick. In the upper part of this sandstone water was encountered, which rose within 50 feet of the mouth of the well. As this is the only sandstone below the 215-foot level which contained water, it suggests that the sandstone bed near the base of the Colorado is too fine grained to permit the ready circulation of liquids.

COLORADO AND CLAGGETT SHALES.

That part of the undifferentiated Colorado and Claggett formations which represents the Colorado consists chiefly of dark-gray to black, somewhat fissile shale, containing some intercalated thin layers of sandy shale and sandstone in its upper part and, according to the interpretation of the driller of the Vananda well, thin beds of limestone and sandstone near the base. The sandy phases observed in the field in the upper part of the formation are not recorded in the log of the well, an omission which indicates that they are either lenticular in character or were overlooked by the driller. In some places the shale contains numerous large limestone concretions, but whether or not these are characteristic of any definite horizon was not ascertained.

That part of the undifferentiated beds corresponding to the Claggett consists of 600 or 700 feet of dark-gray shale that becomes exceedingly plastic when wet. Calcareous concretions occur throughout this part of the formation but are exceptionally prevalent near the top, where many of them show a well-developed cone-in-cone structure. The Colorado and Claggett are so similar in lithologic character that they were not differentiated in this area, the chief distinction between them being the absence of sandy phases in the Claggett and its greater plasticity when wet, less fissile character, and slightly lighter color. The two formations can, perhaps, be accurately differentiated in this area only by a careful study of their contained fossils.

JUDITH RIVER FORMATION.

The Claggett is overlain by sandstone and shale of marine origin, which correspond stratigraphically to the fresh-water Judith River formation farther west. This formation consists of two massive sandstones, separated by an intervening shale, having a total thickness at the head of Porcupine Creek of about 125 feet. Below this there is a sandy transition zone to the typical dark shale of the underlying Claggett. The upper 200 feet of the Vananda well log represents this formation; whether it represents all of the formation or only a part of it is not positively known, but the writer is of the opinion that only a part of the Judith River formation is represented in the well record. If this opinion is correct the formation is eithe considerably thicker at Vananda than in the area in which it wa mapped, or the transition zone to the Claggett has been interprete by the driller as consisting largely of sandstone.

BEARPAW AND LANCE FORMATIONS.

The Judith River is overlain by the Bearpaw shale, which has th same physical and lithologic characters as the Claggett. The Bear paw is succeeded by sandstone and shale of the Lance formatio which are of fresh-water origin.

IGNEOUS ROCKS.

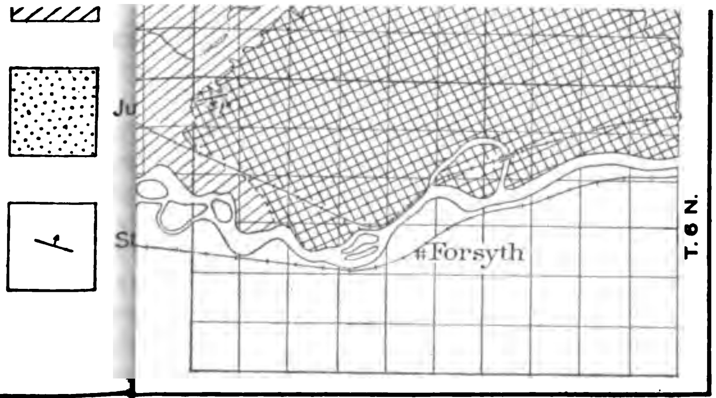
A vertical dike about 9 feet thick and half to three-quarters of mile long occurs on the top of the divide west of Stellar Creek, prob ably near the north boundary of T. 10 N. The dike is a reddish brown vesicular rock containing small flakes of biotite, a conside able proportion of calcite, and numerous inclusions of black shal the largest of which is more than 2 inches in longest diameter. I the thin section this rock is seen to be so thoroughly altered that i original character can not be determined. The matrix consis almost wholly of calcite and ferritic material in which occur blad and flakes of biotite and an occasional small cryptocrystalline phen cryst having about the index of refraction of quartz or feldspa This is the only occurrence of igneous rock noted.

STRUCTURE.

The dominant structure of this area is that of an elongate, rough triangular dome whose outline is indicated by the inner margin the Judith River formation. Within that margin the dome has maximum north-south diameter of about 33 miles and a maximu east-west diameter of 27 miles. Along the east and north sides the dome the Judith River formation dips away from the axis uplift at angles ranging from 1° to 8°, the steeper dips being on th east side. The dips on the west side of the dome have not been accurately determined, but are thought to range from 1° to 4°, except perhaps locally. Minor folds, such as are known to occur farther out in the surrounding plains, may also exist within the domed area, but details of this character have not been worked out.

FACTORS CONTROLLING THE ACCUMULATION OF OIL AND GAS.

For the accumulation of oil and gas there must be (1) a competent source of supply; (2) a proper receptacle for their accumulation and retention; and (3) structural conditions permitting their concentration into a small area (a so-called "pool") from their originally disseminated condition in the rocks in which they originated.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With regard to the source of supply it may be stated, without entering into a discussion of the origin of oil or gas, that they are found in commercial quantities only in sedimentary rocks and probably originated from organic matter entombed within the strata at the time of their deposition. There is also a vague but general impression among geologists that much of the oil and gas now found in pools has been derived from shale, though it is also recognized that fossiliferous limestone and possibly sandstone are also adequate sources of supply.

The presence of oil or gas in the rocks may be indicated at the surface by the occurrence of oil seeps or springs, gas emanations, asphaltic deposits, or rocks impregnated with bituminous matter or emitting a petroliferous odor. The existence of any or all of these surface indications does not demonstrate that oil and gas occur in commercial quantities, as such indications are known in regions which on development have proved to be unproductive. On the other hand, lack of surface indications is by no means conclusive proof that oil and gas do not occur; many of the most productive pools furnish no surface evidence of the existence of oil or gas. It may be laid down as a fundamental principle, therefore, that the existence of oil or gas in commercial quantities can be demonstrated only by the drill.

As originally formed in the parent rock, whatever its character, oil and gas exist in a widely diffused state, and in order to be available for commercial use they must be collected into local areas called pools. That this condition may be realized, a proper receptacle must be available for their accumulation and retention. Such a receptacle consists of a porous medium (sandstone, porous limestone, or fractured shale), hermetically sealed above by some relatively impervious body, such as a bed of shale or clay or a water-saturated stratum.

The existence of a proper receptacle may be ascertained by a surface study of the formations, if these are exposed within or adjacent to the area under investigation, provided the formations or their individual members are continuous in extent. On the other hand, if the beds are lenticular, a surface study of the formations may be of little value in determining the existence of porous members or the depth at which they may be encountered in any particular locality. In such areas the required information, like that regarding the occurrence of the oil, can be obtained only by drilling.

The structural conditions under which gas and oil accumulate are manifold, but in this discussion the simplest conditions are assumed, namely, that the structure is regular and that the oil rock is homogeneous, of continuous extent, and overlain by an impervious cover. Perhaps the only definite statement possible is that oil or gas do not generally accumulate in commercial quantities in strata which are perfectly flat. In order for concentration in commercial quantities to be accomplished, it seems necessary that the strata shall have been flexed, tilted, or folded in some manner. The structural forms which experience has shown to be most favorable are domes, anticlines, terraces, monoclines, synclines, and fissures, named perhaps in the order of their value.

The structural position of gas and oil pools seems to depend largely on the character of the strata, the presence or absence of water, and the character of the oil. Of these factors the degree to which the receptacle is saturated with water seems to be of first importance. Experience has demonstrated that the following statements generally hold good: (*a*) If the strata are saturated with water, the gas and oil, being the lighter, will be forced to the highest available point, and will therefore occupy the crests of domes or anticlines. (*b*) These conditions, however, will be modified if the strata, instead of having a regular dip from the apex to the margins of the dome or anticline, descend irregularly, producing a steplike or "terraced" structure. In this event the oil and gas will be likely to accumulate on the flats or terraces. (*c*) If the receptacle is only partly saturated with water, the oil and gas will occur on the limbs of folds at the upper level of saturation. (*d*) If the strata are dry, the oil and gas will migrate to the lowest available point of the receptacle—that is, to the axis of the syncline, the terraces of a monocline, or the limb of a fold, or to a point where further downward migration is prevented by some other cause. (*e*) If both oil and gas are present in the same stratum, the gas, being the lighter, will usually though not invariably be found above the oil.

Factors tending to modify the above statements are lenticularity of the receptacle, its varying degrees of porosity, variations in the viscosity and specific gravity of the oil, the readjustment of the water level since the accumulation of the oil and gas into pools, subsequent tapping of the pools either by fracturing or erosion, which may allow the accumulated material to dissipate slowly into the air or surrounding strata, and possibly variations in the direction and degree of movement of water in the rocks.

Stated in another way, under the influence of gravity alone oil would migrate to the lowest point of the porous stratum, but as the effect of gravity is modified by the above-named factors the oil collects at the lowest available point, whether this be the axis of an anticline or syncline or some intermediate position.

In applying the foregoing principles to the area under discussion the following facts may be stated: (*a*) There are no known surface indications (oil seeps, gas emanations, asphalt deposits, or strata impregnated with bitumen or emitting bituminous odor) of oil or gas in the area. (*b*) The structure consists of an elongate dome having a north-south extent of about 35 miles and a maximum east-west extent of 25 miles. Around the periphery of the dome the strata, so far as examined, have regular and rather uniform dips of 1° to 8°; at the crest of the dome they are probably almost flat. (*c*) Sandstones which might have been utilized for the accumulation of oil and gas, if such substances were present in the surrounding rocks, occur in the Judith River formation (now eroded from the center of the dome), near the base of the Colorado shale, and in the underlying Kootenai(?). (*d*) Save for the Vananda well this field is entirely undeveloped.

From these facts the following inferences may be drawn: (*a*) The lack of surface indications of oil and gas suggests strongly that these substances do not occur in the Judith River formation, which is exposed at the surface, but is no proof of their presence or absence at the base of the Colorado or in the underlying Kootenai (?), as these formations lie at depths of 2,100 to 2,300 feet below the top of the Colorado shale and probably about 1,500 or more feet below the crest of the dome. (*b*) In so far as the structure alone is concerned, it is favorable for the accumulation of oil and gas into pools. (*c*) The sandstones of the Judith River formation are not probable receptacles of oil or gas, as these sandstones are well exposed in the field and show no indications of the presence of any bituminous substance. (*d*) Oil or gas may or may not occur in the sandstones at the base of the Colorado and in the underlying Kootenai (?). Sandstones at similar stratigraphic positions are oil bearing in Wyoming. The Colorado shale is the chief source of oil in the Salt Creek, Bighorn Basin, and southwestern Uinta County fields and contains small quantities in the Douglas, Moorcroft, and Lander fields. Sandstones underlying the Colorado, ranging in age from Morrison to Dakota and therefore in the approximate position of the Kootenai (?), contain small quantities of oil in the Bighorn Basin, Powder River, Douglas, and Moorcroft fields. But these formations are not known to be oil bearing in Montana, although gas has been found in the Pierre shale near Glendive. (*e*) The failure of the Vananda well to encounter oil or gas (so far as the record available to the writer indicates) does not conclusively demonstrate the absence of these substances, because the Vananda well is on the southwest flank of the dome and so far as known is not on a structural terrace or other irregularity. In dry rocks, therefore, such as the sandstone at the 3,050-foot level, the oil if present would be likely to accumulate farther down the slope; whereas in saturated rocks, such as the sand at the 3,200-foot level, oil if present would be more likely to accumulate farther up the slope, at the top of the water level.

Opposed to the favorable structural and stratigraphic conditions and the presence of formations known to be oil bearing in other regions is the fact that not a single promising occurrence of oil is known in the State. In fact, with a few exceptions, not even traces of oil have thus far been discovered. This is largely true also regarding gas, though indications of gas are more numerous than those of oil, and it is reported that gas was encountered in considerable quantity in the well put down by the Northern Pacific Railway Co. near Glendive.

The apparent scarcity of oil and gas in Montana may be due in part to lack of proper and adequate exploration, but it may also be due to the absence of these substances in the strata.[1]

CONCLUSIONS.

The presence or absence of oil or gas in the Porcupine dome field can be demonstrated only by thorough and systematic exploration with the drill. The only positive statement that can now be made regarding their possible occurrence is that the structural and stratigraphic conditions are favorable for their accumulation. The most promising place, in the opinion of the writer, for testing the field is near the crest of the uplift; that is, on the divide between Porcupine and Little Porcupine creeks, probably in Tps. 10 and 11 N., R. 38 E., because the underlying sandstones come nearest to the surface there and because the water encountered in the sandstone 3,200 feet below the mouth of the Vananda well is believed to saturate that stratum, and would therefore force the oil and gas, if present, to the crest of the anticline. The mouth of the Vananda well has an altitude of 2,704 feet above sea level. As the water encountered in the sandstone at the 3,200-foot level rose within 50 feet of the surface, the water level in this sandstone is about 2,650 feet above the sea, and hence if oil occurs in the sandstone it would be expected to occur at or below that level. Nothing is known of the attitude of the rocks so far below the surface, but if they are approximately parallel to those at the surface, it is probable that the water-bearing sandstone does not reach an altitude of much more than 2,650 feet in any part of the dome; therefore it is a fair inference that the water-bearing sandstone is completely saturated with water, and if it contains oil or gas they will be found at the crest of the sandstone and near its upper surface. For this reason it is advisable to drill near the axis of the dome, which, as suggested above, is probably in Tps. 10 and 11 N., R. 38 E. It can not be emphasized too strongly that the existence of oil or gas in this field is at present merely conjectured from the favorable structure and the fact that formations of the same age and character as those represented here are known to contain oil in other places. Under these circumstances nothing but systematic and intelligent exploration should be undertaken and all haphazard ventures should be discouraged, at least until some conclusive results have been obtained.

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[1] About the time this report went to the printer gas was obtained in a well at Havre. This development has been examined by a geologist of the Survey, and a report on it is in preparation.

THE LAWTON OIL AND GAS FIELD, OKLAHOMA.

By Carroll H. Wegemann and Ralph Howell.[1]

INTRODUCTION.

The Lawton oil and gas field, in Comanche County, Okla., is situated near the eastern end of the Wichita Mountains, about 5 miles east of the city of Lawton. (See Pl. XI and fig. 3.) In the early days of Lawton, in 1901, interest among the settlers is said to have been aroused by the finding of oil in a well dug for water on C Street near what is now the Midland Hotel. This well was 60 or 70 feet deep and its water was so tainted by petroleum that the well was finally abandoned and filled in. In 1904 a well about 90 feet deep is reported to have been put down in the southern part of the city which produced 3 or 4 barrels of oil a day. The oil was sold in Lawton for a period of two or three years.

Drilling for oil in the field 5 miles east of Lawton was begun in 1904 and has been continued intermittently up to the present time, but the field has not produced either oil or gas in commercial quantities. About 50 wells have been drilled, more than 20 of which are less than 500 feet in depth.

The writers desire to express their indebtedness to the oil companies operating in the Lawton field, which have furnished logs of their respective wells; also to many citizens of Lawton who extended courtesies during the prosecution of the field work.

TOPOGRAPHY.

The Lawton field lies in the open plains region of Oklahoma. After the reduction of the surface to a plain by erosion uplift occurred, and the present streams have cut moderately deep valleys below the upland surface. The field is drained by Cache Creek, which rises in the area north of the Arbuckle Mountains and flows southward to Red River. The general altitude of the country is about 1,100 feet.

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[1] The following report has been prepared by the United States Geological Survey under a cooperative agreement with the Oklahoma Geological Survey according to which each furnished a part of the funds necessary for the work.

STRATIGRAPHY.

The Lawton field is only 8 miles from the Wichita Mountains, and a discussion of its stratigraphy involves a brief description of the geology of the mountain area. The Wichita Mountains consist of a core of igneous rock which is surrounded by steeply dipping strata of early Paleozoic age. At the east end of the uplift the only representative of these strata which reaches the surface is a limestone formation of Cambrian and Ordovician age, approximately 5,000 feet thick, known as the Arbuckle limestone. The granite and limestone of the mountains rise abruptly from the surrounding plain like islands in a sea. Against them and evidently covering part of their mass lie the almost horizontal strata of the Permian "Red Beds," which form the surface rocks in the Lawton field, as well as in all the area surrounding the mountains.

The "Red Beds" consist of alternating layers of shale and sandstone and, associated with the sandstone, thin layers of shale conglomerate whose pebbles consist of the same material as the shale forming the principal part of the series. Near the base of the Permian, as exposed along the Wichita Mountains, there are several thin beds of limestone only a few inches in thickness. The shale of the Permian is predominantly red, but bluish-gray shale is present, especially near the base of the series. The sandstone is white and in some places red or pink. The Permian strata bear very few fossils, and none were collected in the Lawton area, although the remains of primitive amphibians and sharks as well as fossil plants have been found farther south.[1]

The most prominent bed or group of beds in the Lawton field structurally and stratigraphically is the sandstone that forms the low rounded hills east and north of the gas wells. Its outcrop may be traced for 12 to 15 miles northwest of the Lawton pool and probably much farther along the north flank of the Wichita Mountains. The individual beds of sandstone are lenticular, being interbedded with shale, but the group as a whole appears to be continuous over a large area in this part of the State. It occupies about the same stratigraphic position as the sandstone that forms the high ridge 6 miles north of Loco, in which grahamite was at one time mined in sec. 6, T. 2 S., R. 4 W., and also the prominent wooded ridge extending across T. 1 S., R. 5 W., in the direction of the Duncan gas field. In the Lawton field the sandstone is barren of timber. This sandstone is about 200 feet thick. Some 400 or 500 feet above it lies the sandstone that forms the escarpment about the Duncan gas field, as well as the line of hills 6 miles northeast of the Lawton field.[1] The rocks between these two sandstones are predominantly shale.

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[1] Wegemann, C. H., Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, pp. 25-27, 1915.

The character of the strata which underlie the surface in the Lawton field is indicated by the logs of the gas wells. Alternating beds of sandstone and shale, the shale for the most part red in color, extend to a depth of about 1,150 feet. At 1,165 feet in Marple well No. 4 of the Lawton Natural Gas Co. is recorded a bed of solid limestone, which was penetrated to a depth of 65 feet. As no limestone beds of such thickness are known in the Permian in this region, this bed presumably belongs to a formation older than the Permian and is doubtless separated from the red shale which lies above it by an unconformity as great as that which is to be observed along the mountains a few miles to the northwest, where the Permian with a well-developed basal conglomerate unconformably overlies all older beds. That this unconformity at the base of the Permian is merely local in extent and is confined to the vicinity of the Arbuckle-Wichita Mountain uplift is indicated by the fact that in Clay County, Tex., where the base of the Permian is also exposed, the Cisco formation, the highest division of the Pennsylvanian, appears to be conformable with it.[2] The unconformity at the base of the Permian in the region of the Lawton field is economically important, as it may have had much influence on the accumulation of the oil. (See pp. 76–78.)

STRUCTURE.

The Wichita and Arbuckle uplifts are of the nature of great arches or anticlines, the free Permian sedimentary rocks which now are exposed along their margins having at one time extended completely over their crests. The mountains appear to have been produced by at least two uplifts—the first at the close of Mississippian time and the second at or near the end of Pennsylvanian time. Each uplift was followed by erosion and degradation of the mountain mass, and the Permian strata were formed of the materials removed from the mountains after the second uplift. Since the deposition of the Permian beds, perhaps in very recent geologic time, the Arbuckle-Wichita axis has been subjected to very slight uplift, which has bent the Permian strata covering the region between the two ranges into what appears to be a low anticlinal arch. Only the north limb of this arch can be recognized, because only north of the axis are the rock strata sufficiently well exposed to make geologic observations possible.

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[1] Wegemann, C. H., The Duncan gas field, Stephens County, Okla.: U. S. Geol. Survey Bull. 621, pp. 9-50 (Bull. 621-D).

[2] Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 574 p. 8, 1914.

The Lawton oil and gas pool lies about 8 miles southeast o southeast end of the Wichita Mountains, on the axis of the arch just described. As will be apparent from an examinatio the map (Pl. XI), the folds on which oil and gas occur are b means simple ones. The type of irregular folding is the sam that which has been found to exist in the Healdton and Loc and gas fields, as well as in areas examined in Tillman, Cotton Jefferson counties, Okla.[1]

The principal anticlinal axis in the Lawton field extends s eastward from the Wichita Mountains and is interrupted by a n syncline which crosses it almost at right angles, and which pro contains a small subsidiary dome in sec. 31, T. 2 N., R. 10 W. of this dome lies the continuation of the principal axis of the Southeast of the Lawton field, because of the absence of exposures, the exact position of the anticlinal axis connectin two mountain uplifts can not be determined.

The marked escarpment formed by the group of sandstone b the vicinity of the Duncan gas field, 10 miles east of the to Duncan, westward to a hill 1 mile north of the town, thence westward across the northeastern part of T. 1 N., R. 8 W., a southwestern part of T. 2 N., R. 8 W., and thence in a due nort direction past the northeast corner of the Fort Sill Indian Re tion to the region northeast of the Wichita Mountains. From mountains it is about 6 miles distant. Along the escarpme beds dip at angles of 1° or less toward the northeast, and the s in most places covered with post oak.

The lower group of sandstone beds which form the hills jus of the wells in the Lawton field are not in this area timber co so that the region between the escarpment of the upper gr sandstone beds and the oil wells is almost treeless. Ten miles east of the wells, however, in sec. 24, T. 1 N., R. 9 W., a san bed which appears to be of considerable thickness is exposed a surface is covered with oak timber similar to that which cove surface formed by the upper group of sandstone beds. It seem probable that the sandstone exposed in sec. 24 represents this group and lies either on the crest of the arch between the Ar and Wichita uplifts or south of it. From sec. 24 the edge timbered area may be traced southeastward, and in sec. 32, T. R. 8 W., there appears to be a slight dip to the south or sout The axis of the Wichita-Arbuckle fold probably lies a mile northeast of this locality, and as its trend is southeasterly it pro passes about a mile southwest of the town of Duncan.

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[1] Wegemann, C. H., and Heald, K. C., The Healdton oil field, Carter County, Okla.: U. S. Geol Bull. 621, pp. 13-30, 1915 (Bull. 621-B). Wegemann, C. H., The Loco gas field, Stephens and counties, Okla.: Idem, pp. 31-42 (Bull. 621-C). Munn, M. J., Reconnaissance of the Grandfield Okla.: U. S. Geol. Survey Bull. 547, 1914. Wegemann, C. H., Anticlinal structure in parts o and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, 1915.

INTERPRETATION OF STRUCTURE CONTOURS.

The structure contours given on Plate XI are drawn on the surface of the "400-foot gas sand" (see Pl. XII), which appears to be the equivalent of the principal gas sand in the Duncan field. As the contours in the Duncan field are drawn on the same horizon the maps of the two fields may be easily compared.[1] The contours represent the shape of the folded surface of the bed on which they are drawn. Every point along any one contour is at the same elevation above or below sea level, the lines being drawn at intervals of 20 feet. To one unfamiliar with the interpretation of contours the following somewhat fanciful conception may be of assistance.

Were it possible to remove all the overlying strata and to walk about on the surface of the oil sand, the course followed by one who endeavored to walk always at an elevation of 800 feet above the sea, never stepping up or down, would be that indicated by the 800-foot contour on the map. When the pedestrian came to a knoll or jutting point he would be compelled, if he did not wish to ascend, to walk around its side. When he crossed the valley which lay between this knoll and the next he would be compelled, if he did not wish to descend, to walk up the valley to a point where its floor was level with that of the hillside which he had just left. In other words, his course, were it indicated by a line, would represent the form of the hills and valleys or their contour. A series of lines drawn at regular intervals above sea level shows very clearly, to one accustomed to the reading of contours, the form of the surface which they represent.

OIL AND GAS.

POSITION OF OIL SANDS.

Oil and gas are found in the wells of the Lawton field in three different sands, which are known in the field as the "200-foot," "400-foot," and "800-foot" sands. The "200-foot sand" is from 10 to 30 feet thick, and lies at depths of 150 to 250 feet, according to the location of the well with reference to the Lawton anticline. This sand has been found in the greater number of the wells and generally carries at least a show of oil. In some wells a production of several barrels of heavy oil is reported from this sand, and in at least three of the wells gas is reported from it, though only in small quantity. In sec. 25, T. 2 N., R. 11 W., and sec. 30, T. 2 N., R. 10 W., there is a second sand from 60 to 75 feet below the first one which also has yielded a show of oil. This sand, however, is recorded in only three of the well logs.

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[1] Wegemann, C. H., The Duncan gas field, Stephens County, Okla.: U. S. Geol. Survey Bull. 621, pp. 43–50, 1915 (Bull. 621–D).

The "400-foot sand," which appears to be recognized in a
wells that are deep enough to reach it, is found at 350 to 45
below the surface. Where it occurs as a single stratum it ran
thickness from 6 to 30 feet. In certain wells two sands are fo
about this horizon and are separated by shale from 5 to 60 feet
This sand is reported to yield from 10 to 15 barrels of oil in c
wells, and in Marple No. 2 of the Lawton Natural Gas Co. a flo
obtained from it, though lasting only a short time. The oil a
to be somewhat lighter in gravity than the oil found in the sha
sand. In some of the wells gas is reported in the "400-foot s
Marple No. 1 of the Lawton Natural Gas Co. had an initial f
660,000 cubic feet. In other wells the production has been esti
as high as 1,000,000 cubic feet, but no accurate measurements s
to have been made to support these estimates. From a comp
of well logs it is believed that the "400-foot sand" in the L
field is the approximate equivalent of the main gas sand in the
can field.[1]

The "800-foot sand," which has been penetrated in only 13
appears to be the most promising source of oil and gas in the
It ranges in depth from 750 to 850 feet and is variously repor
one bed of sandstone about 90 feet thick or as several beds sep
by shale. In the Havic & Hall well, on the Epstein farm, i
SW. ¼ NW. ¼ sec. 32, T. 2 N., R. 10 W., this sand was encountere
depth of 756 feet. In the top 12 feet the sand carried oil;
came a soft shaly sandstone 14 feet thick, which was impreg
with asphalt; and the lowest 60 feet carried oil, but in small qua
In the Reading well, in the SE. ¼ NW. ¼ sec. 29, T. 2 N., R. 1
on the Kadie farm, the sand was struck at a depth of 763 feet,
feet thick, and carried gas with an estimated initial flow of 1,00
cubic feet. Below the sand is 38 feet of hard red rock, wh
underlain by 10 feet of sand that did not yield gas. Below this
is a gas sand, which was penetrated only 1 foot and which is s
have had a rock pressure of 400 to 500 pounds to the square
and an initial flow of gas of 4,000,000 cubic feet. In the well o
Lawton Imperial Oil & Gas Co., in the NE. ¼ NW. ¼ sec. 26, T.
R. 11 W., the sand was struck at a depth of 800 feet. The fir
feet yielded a show of oil, but the next 33 feet carried water.

ORIGIN OF THE OIL AND GAS.

If, as is now generally believed, oil and gas are derived from org
remains, it is evident that rocks that were deposited in water
which life abounded are to be considered a more probable sour
oil than those that give little evidence of the existence of plant

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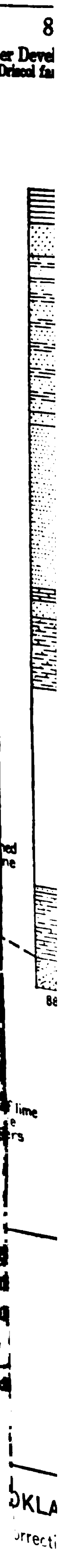
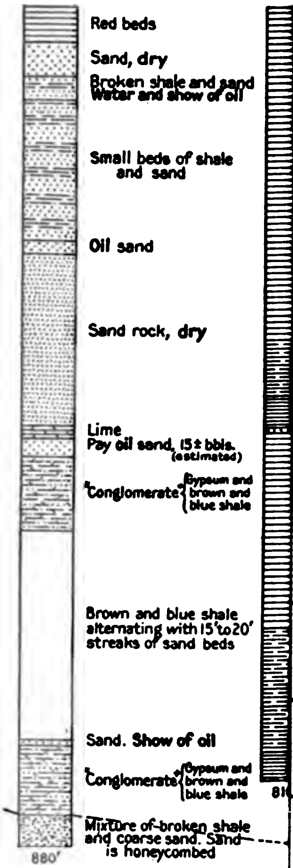
[1] Wegemann, C. H., The Duncan gas field, Stephens County, Okla.: U. S. Geol. Survey Bull. 6
43-50, 1915 (Bull. 621-D).



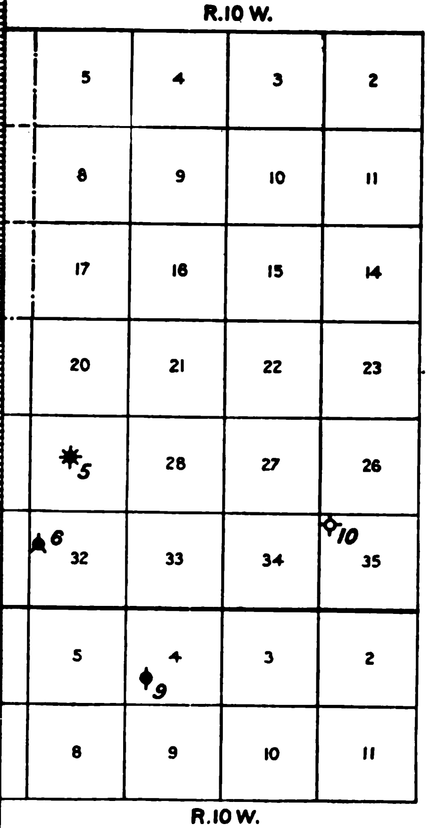
8

ner Development Co.
Driscol farm No. 1

Vosle


Red beds
Sand, dry
Broken shale and sand
Water and show of oil
Small beds of shale and sand
Oil sand
Sand rock, dry
Lime
Pay oil sand, 15± bbls. (estimated)
Conglomerate
Gypsum and brown and blue shale
Brown and blue shale alternating with 15' to 20' streaks of sand beds
Sand. Show of oil
Conglomerate
Gypsum and brown and blue shale
Mixture of broken shale and coarse sand. Sand is honeycombed
880'
81

ned
ne



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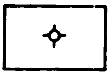
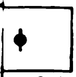


Dry hole



w of oil

KLA., DRILLED TO

rection. Many of the depths

animal life at the time of their formation. The Permian "Red Beds" carry very few fossil remains compared with the rocks of the preceding series, the Pennsylvanian. For this reason, if for no other, the Pennsylvanian rather than the Permian might be considered as the source of the oil and gas which are found in the Permian. Moreover, the Pennsylvanian is known to include in northern Oklahoma a great oil-bearing formation, and when this fact is taken into consideration, it seems more than probable that from the Pennsylvanian rocks were derived the oil and gas that are now found in the Permian strata in southern Oklahoma.

If the oil and gas of the Lawton field were derived from Pennsylvanian rocks, they probably rose along the steeply rising beds of the Pennsylvanian to the unconformity which exists between the Pennsylvanian and the overlying Permian. This unconformity marks an old erosion surface on which flat-lying sediments with probably a basal conglomerate were deposited, and these sediments doubtless are porous strata along which oil or gas might easily migrate. As the old erosion surface was somewhat irregular, sandstone beds in the lower part of the Permian probably terminate against its irregularities, making it easy for oil flowing along the unconformity to find its way into the sandstone beds of the overlying formation without being compelled to pass through strata of comparatively impervious shale. Were the sandstone beds of the Permian gently folded so that the influence of anticlinal structure would accelerate accumulation, the oil (or gas which later condensed into oil) might traverse these beds for several miles before at last finding lodgment near the crest of the anticline. Under such conditions the strata in which the oil was originally formed would not necessarily immediately underlie the place of accumulation.

The Lawton oil and gas pool lies 5 miles southeast of an outcrop of Arbuckle limestone, of Cambrian and Ordovician age, the beds of which dip 4° SE. and strike N. 35° E. As the thickness of the beds between the top of the Arbuckle limestone and the base of the Pennsylvanian is approximately 5,000 feet, it is evident that if the dip of 4° holds for any considerable distance east of the outcrop of Arbuckle limestone mentioned above, the beds of the Pennsylvanian would lie at a distance of much more than 5 miles east of the Lawton field. Even were the dip of the rocks considerably steeper than 4°, the Pennsylvanian would hardly underlie the region of the oil and gas wells. It is, of course, possible that this area may contain faults, which may throw the Pennsylvanian very much nearer to the mountain uplift than it would be under conditions of regular folding. The occurrence, however, of asphalt in a zone encircling the Wichita Mountains and at about the same distance from them as the Lawton pool would suggest that the same general conditions prevail on all sides of the mountains and that the presence of faults is improbable.

There is a possibility that the oil and gas in the vicinity of the Wichita Mountains, as well as the asphalt, which is the residuum left by the evaporation and oxidation of petroleum, were derived from rocks older than the Pennsylvanian, perhaps from the Arbuckle limestone. In the deep well known as the Mineral Springs well, in the SE. ¼ NE. ¼ sec. 21, T. 2 N., R. 11 W., thick limestone beds, presumably those of the Arbuckle limestone, were encountered at 440 feet. (See Pl. XII.) "Showings" of oil are reported at 1,935 and 2,200 feet, and there seems little question that the beds in which it was found also belong to the Arbuckle limestone. On the south side of the SE. ¼ sec. 17, T. 2 N., R. 12 W., a bed of sandstone in what is presumably the Arbuckle limestone is impregnated with oil, but the oil in this locality may have come from overlying Permian beds that have since been removed by erosion.

The fact that the Arbuckle limestone is oil bearing of course does not preclude the Pennsylvanian from being also a source of oil and gas—probably the principal source in the region.

QUALITY OF THE OIL AND GAS.

No samples of the oil in the Lawton field were obtained. Oil from the "800-foot sand" is reported to test as high as 44° Baumé, but this test has not been verified. Oil in the shallower sands is of higher specific gravity (lower Baumé). A sample of gas from the "800-foot sand" was obtained and has been analyzed by the Bureau of Mines as indicated below.

Analysis of gas from the Redding No. 1 Kadie well, SW. ¼ NW. ¼ sec. 29, T. 2 N., R. 10 W., Lawton field, Okla.

[Collected Oct. 19, 1914. Laboratory No. 5863.]

CO_2	0.2
CH_4	90.5
C_2H_6	7.1
N_2	2.2
	100.0

Specific gravity (air=1) 0.60.

Heating value at 0 °C. and 760 millimeters pressure, 1,096 British thermal units.

PROSPECTING IN THE LAWTON FIELD.

The early history of the Lawton field from its discovery to the autumn of 1910 is given in the following extract:[1]

> The first well was located on the N. ½ NW. ¼ sec. 6, T. 1 N., R. 10 W., just 5 miles east of Lawton. It was completed in August of 1904 at a depth of 400 feet and had an initial rock pressure of 125 pounds and a production of about half a million cubic feet of gas per day.

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[1] Hutchison, L. L., Preliminary report on the rock asphalt, asphaltite, petroleum, and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 2, pp. 241-242, 1911.

During the same year the company completed a well southeast of their No. 1. Gas was not found, as had been anticipated, but a light production of black oil was obtained. Nothing more was done in the pool until 1906, when a dry gas well was drilled in the E. ½ NE. ¼ sec. 1, T. 1 N., R. 11 W., being less than a half mile from the first one. It had an initial rock pressure of 100 pounds and produced a little less than a half million cubic feet of gas per day.

The third well drilled by the Lawton Co. was on the N. ½ NW. ¼ sec. 6, a location southeast of the first gas well. Oil was found at a depth of 320 feet. Packers were so set as to save the oil, and the well was drilled on to the 400-foot sand, where gas was found. The initial rock pressure was about 100 pounds, and the well is estimated to have produced 300,000 cubic feet per day, while the oil produced from the 320-foot sand originally amounted to about 15 barrels daily. A pump has been installed and the well is still producing a little oil.

The same company's well, No. 5, was drilled during 1906 in the N. ½ NE. ¼ sec. 1, a few hundred feet northwest of No. 3. Oil was found at a depth of 400 feet. The capacity has never been tested, though oil is reported to be standing within 30 feet of the top.

The next well drilled was 200 feet to the southwest of No. 5 and was brought in during 1906 as a dry gasser at a depth of 400 feet. In 1907 the well tested nearly 450,000 cubic feet per day.

Well No. 7 was drilled during December, 1906, a few hundred feet southwest of the one last mentioned. Oil of an estimated capacity of 2 or 3 barrels a day was found at a depth of 250 feet. Drilling continued to a depth of 390 feet, where the gas was found and the well completed as a gasser.

The last well reported by this company was completed during January of the present year [1910]. Showings of oil were encountered at 225 and 250 feet, but the sand was dry at 380 feet. Owing to the general topography of the region the sand at 380 feet appears to be the regular 400-foot sand, so it is probable that this will ultimately prove to be a dry hole.

Besides the wells already enumerated, the Lawton Natural Gas Co. drilled one in the E. ½ NW. ¼ sec. 6. It was completed during 1907 and produced oil in the 400-foot sand, but has since been abandoned.

A partial list of the wells which have been drilled in the field and the companies which own them is given below.

	Wells.
Lawton Natural Gas Co.	11
Boone & Warner	4
Epstein Oil Co.	4
Deming Investment Co.	3
Night and Day Oil Co.	3
Havic & Hall	2
Owen, Wilson & Chaffee	2
Companies having only 1 well each in the field	14

Notwithstanding the number of wells that have been drilled in this field, the pool has not yet been thoroughly prospected. The "800-foot sand," which appears to be the bed from which the greatest production is to be expected, has been reached in only 13 of the wells. Of these almost half have been drilled in localities that are geologically unfavorable. The highest part of the anticline in the field lies in the SW. ¼ sec. 28, the SE. ¼ sec. 29, the NE. ¼ sec. 32, and the NW. ¼ sec. 33, T. 2 N., R. 10 W. This anticline has been tested by three wells in sec. 29, T. 2 N., R. 10 W., all of which are among the best in the field, and there is no reason why the quarter sections named above should not produce equally good wells. A dry hole has been drilled in the NW. ¼ sec. 35, T. 2 N., R. 10 W., so that it is probable that the oil and gas pool does not extend far to the southeast. The area mentioned as most promising should be tested first, and if it is found productive the pool should be traced by carefully spaced wells in a direction a little south of east from the SE. ¼ corner of sec. 29, T. 2 N., R. 10 W.

The crest of the small dome lying in sec. 31 (see Pl. XI, p. 74) has not been tested by wells that reached the lowest sand, although wells that obtain showings of oil in this sand have been drilled east and northwest of it. Before the dome can be regarded as fully tested, one well deep enough to reach the "800-foot sand" should be drilled on the crest of this dome, as indicated on Plate XI. A test might also be made in the NW. ¼ sec. 24, T. 2 N., R. 11 W., northwest of the asphalt seep that occurs near the center of the section, although this territory is probably not so promising as that 2 miles southeast of it.

It is reasonable to believe that by careful testing of the areas outlined on Plate XI a profitable though small field may be developed in the Lawton anticline which will supply sufficient gas for the use of Lawton and give a moderate production of oil. Whether or not oil exists on the low arch of the Permian strata between the Wichita and Arbuckle uplifts it is impossible to say. The crest of this arch can not be very accurately defined but probably extends from the Lawton field east and south to the southeast corner of T. 2 N., R. 10 W., thence to about the middle of the east line of T. 1 N., R. 9 W., and from this point southeastward, passing south of the town of Duncan. Prospecting along this axis, while it may be productive of valuable results, will probably be very hazardous financially and should be undertaken only by companies that can well afford to risk considerable sums in such work.

ASPHALT SEEPS AND OCCURRENCES OF OIL AND GAS IN THE VICINITY OF THE WICHITA MOUNTAINS.

No report on the Lawton field would be complete without mention of the numerous asphalt seeps and showings of oil and gas which occur in the region of the Wichita Mountains within and near the field.

Asphalt is formed by the evaporation and oxidation of petroleum, and its occurrence is in itself an indication of the presence of petroleum, now or in times past, in the vicinity, although not necessarily immediately below the seep. It is not to be regarded as proof of the presence of petroleum in commercial quantity. An asphalt seep may be derived from only a small accumulation of petroleum, or the reservoir which furnished the asphaltic material may have been drained of the greater part of its contents by the asphalt seep itself. The possibility of the migration of the oil for considerable distances along the sandstone beds of the Permian has been suggested on page 77, and it is evident that the oil from which the asphalt seeps were formed may have traveled for a considerable distance from its original source. The same is true of the "showings" of oil or gas which are observed in many wells sunk for water. Although such indications are found in most large oil fields, yet they may also be observed in many places in which oil and gas do not occur in commercial quantity.

A list of the occurrences of oil, gas, and asphalt in the vicinity of the Wichita Mountains, with a brief description of the localities, is given below.

T. 2 N., R. 11 W.

SW. ¼ NE. ¼ sec. 21 (elevation of asphalt, 1,089 feet), in the east bank of the creek a little north of the junction of the main stream with a small draw entering from the east. Here fine shaly sandstone is impregnated with and smells of petroleum for approximately 150 feet along its outcrop. The layers of shaly sandstone carrying the petroleum are not over 6 inches thick and are interbedded with shale that does not show oil. At one place asphalt oozes from the containing rock. There are small faults in the beds here, but no pronounced break. The oil probably migrates to the surface along joints or small fault planes. About 10 feet above the asphalt is dark-red shale. Underlying this and including the sandy layers bearing the asphalt is greenish-gray shale which weathers to gumbo.

SW. ¼ NE. ¼ sec. 24, asphalt impregnating a bed of sandstone which is also exposed on several rounded knolls a mile or so to the northwest. The outcrop occurs at the head of a small draw draining toward the northwest which has been dammed to form a "tank," or water reservoir. The rock is a medium-grained sandstone, of which 3 or 4 feet is exposed at the surface and a greater thickness is probably concealed. The impregnation with asphalt or oil is so thorough that specimens of the rock are plastic and sticky. This asphaltic rock has been quarried.

NE. ¼ NE. ¼ sec. 24. In the bottom of a small draw opening southward just south of the Fort Sill Military Reservation a small spring issues from sandstone, and the surface of the water is covered with a scum of heavy oil, which is seen also on the bed of the draw for a few feet downstream. Apparently the oil comes from some bed beneath the sandstone exposed at the surface, for this rock shows no impregnation of oil.

T. 3 N., R. 11 W.

SW. ¼ NE. ¼ and SW. ¼ NW. ¼ SE. ¼ sec. 9. In three small southward-opening draws that drain the S. ½ sec. 10 seepages of asphalt or asphaltic oil occur at about the same elevation, as if derived from one bed. The asphalt flows out of joints in red shale about 3 feet below a conglomerate of shale and sandstone. This conglomerate forms the base of a mass of sandstone which is probably the same as that capping the higher rounded knobs in sec. 14, T. 2 N., R. 11 W., and also that in which the asphalt occurs in sec. 24, T. 2 N., R. 11 W. The most westerly seep arises in an oil-soaked mud cone which holds about a pailful of thick black asphaltic oil. About 150 feet down this draw to the south sulphur water issues from a small spring.

T. 4 N., R. 11 W.

SE. ¼ SW. ¼ sec. 30. A dug well 72 feet in depth is reported to have struck dark heavy oil amounting to 4 or 5 barrels.

SE. ¼ NE. ¼ sec. 32. About 10 feet of asphaltic sandstone, containing conglomerate in certain layers, is exposed in the bed of the creek. Asphalt impregnates several layers of the sandstone. The beds dip about 1° N. or NE. and are about 40 feet below the base of the sandstone which caps the highest rounded knob in sec. 14, T. 2 N., R. 11 W.

NW. ¼ NW. ¼ sec. 34. It is reported that in a well drilled to a depth of 500 or 600 feet enough gas was encountered to burn for three weeks with a flame that could be seen for some distance. The report has not been verified.

NW. ¼ SW. ¼ sec. 26. About 8 feet of sandstone, some of which is impregnated with asphalt, is exposed east of the schoolhouse, on each side of a draw opening to the north. The rock has been quarried and is said to have been used in Lawton for paving. The sandstone probably represents one of the upper beds of the sandstone outcropping in the high knob of sec. 14, T. 2 N., R. 11 W.

T. 2 N., R. 12 W.

NW. ¼ NE. ¼ sec. 34. On the west side of a southward-flowing stream 8 to 12 feet of fine-grained and much cross-bedded sandstone is exposed. Asphalt impregnates the beds irregularly and appears to be more abundant in the thicker layers. Asphalt-bearing sandstone in considerable amount has been quarried at this locality for use in paving the streets of Lawton.

SW. ¼ NW. ¼ sec. 21. On both sides of a small draw which runs north about 10 feet of sandstone is exposed and is underlain by red shale. The sandstone is fine grained, somewhat cross-bedded, and irregularly impregnated with asphalt. It has been prospected by small open pits about 4 feet in depth.

SE. ¼ SE. ¼ sec. 17. Asphalt impregnates sandy layers or lenses in a sandy limestone in the roadbed where the east-west section line crosses the limestone, which is exposed in a ridge to the southwest. The exposure occurs on the north side of the road where the road has been graded.

T. 3 N., R. 12 W.

Oil occurs along the bed of a draw opening east into Cache Creek in the Fort Sill Military Reservation, in what would be the NE. ¼ sec. 29 were the land sectionized. The oil is contained in a cemented breccia or conglomerate of granitic rock that crops out along the creek bed and on its banks and may represent the basal conglomerate of the Permian. The outcrop lies close to the granite area. It is probable that the presence of the oil is due either to upward migration from some source farther to the east (see p. 77) of petroleum along the unconformity at the base of the Permian or to downward migration from "Red Beds" that formerly covered this area but have been removed by erosion. The rock, which is composed of fragments of altered rhyolite, yields on heating in a test tube a light-yellow oil.

T. 5 N., R. 12 W.

NE. ¼ NE. ¼ sec. 7. Oil is reported in a water well at 70 feet.

NE. ¼ NW. ¼ sec. 17. Oil is reported in a drilled well at 250 feet.

T. 2 N., R. 13 W.

SW. ¼ SW. ¼ SE. ¼ sec. 15. On the west bank of a stream flowing southeast a large ledge of massive sandstone is impregnated in some layers with asphalt.

SW. ¼ SW. ¼ NE. ¼ sec. 22. Farther down the same stream what is probably the same massive sandstone bed outcrops in one small exposure on the northwest bank and bears asphalt.

T. 5 N., R. 13 W.

NE. ¼ NE. ¼ sec. 6. "Wildcat" well. No information is available.

T. 1 N., R. 14 W.

NW. ¼ NW. ¼ sec. 1. A dug well is said to have shown oil at a depth of 10 feet. When examined no trace of oil was seen.

SW. ¼ SW. ¼ SW. ¼ sec. 2. In grading the road across a sandstone outcrop a small spring was opened which when first discovered is said to have smelled of oil. No trace of oil was apparent at the time of examination.

T. 2 N., R. 14 W.

SE. ¼ sec. 36. On both sides of the creek flowing southeastward across the section are exposures of massive sandstone. Asphalt is reported from one place on the southwest bank of the creek, but no asphalt could be found on examination.

NE. ¼ NE. ¼ NW. ¼ sec. 24. North of the town of Cache a well drilled in 1904 is reported to have obtained a show of oil at a depth of 500 feet or more.

SE. ¼ SE. ¼ sec. 25. A well is reported to have shown oil. No indications were observed on examination.

T. 5 N., R. 14 W.

SE. ¼ SE. ¼ sec. 18. Oil occurs in a water well.

T. 6 N., R. 14 W.

SW. ¼ SW. ¼ sec. 32 (J. H. Madden farm). Oil is reported in a water well.

T. 6 N., R. 15 W.

SE. ¼ SE. ¼ SW. ¼ sec. 23 (Fox farm). Oil is reported to have been struck in a well at a depth of 75 feet, in 7-foot sand. Oil is said to have been bailed from this well.

NW. ¼ NW. ¼ sec. 23. "Showing" of oil is reported in a well 90 feet deep.

SW. ¼ SW. ¼ sec. 23. Oil is reported in a well at a depth of about 100 feet, in sufficient quantity to be used in the vicinity.

NW. ¼ sec. 13. Gas is said to have been encountered in a water well on the Underwood farm.

NW. ¼ sec. 11. Scum of oil occurs on water in a well on the Van Kirk farm. Southeast of this well is another which has a slight flow of water, and three "showings" of oil are reported from the well in 400 feet.

SW. ¼ sec. 12. A water well on the T. A. Cook farm is said to have showed traces of oil and gas. Oil was struck at a depth of 280 feet.

NW. ¼ sec. 2. Oil is reported in a well on the Givens farm.

SE. ¼ SE. ¼ sec. 19. A showing of oil was seen at the time of examination in a well 42 feet deep on the Reynolds farm. After the well is pumped nearly dry, globules of oil may be observed on the water.

SE. ¼ sec. 29. Water in a well about 80 feet in depth is reported to show a "rainbow" of oil.

SW. ¼ SW. ¼ sec. 31. "Showing" of oil is reported in a water well. Sugar Creek flows across E. ½ secs. 32 and 29, and oil is reported to seep from its banks in warm weather. The report was not verified.

T. 7 N., R. 15 W.

NW. ¼ sec. 13. A 40-foot well in this section is said to have struck a "pocket of oil" in drilling for water. The report was not verified.

NW. ¼ sec. 24. A well 1,000 feet deep on the Franklin farm is said to have struck oil and gas at about 900 feet. The well is now flowing fresh water.

T. 1 S., R. 10 W.

NE. ¼ sec. 27. In a draw which discharges northeastward across the NE. ¼ sec. 27 several thin ledges of sandstone crop out. At one place a specimen was collected from which a light-yellow distillate of petroleum was obtained, on heating in a test tube.

OIL WELLS IN GOTEBO FIELD.

The oil and gas field of Gotebo lies at the northwest end of the Wichita Mountains in a position somewhat similar to that of the Lawton field. The field was not studied in detail, but for the sake of comparison the tracts in which oil wells have been drilled are given below.

T. 7 N., R. 16 W.:
  NE. ¼ NW. ¼ and NW. ¼ NE. ¼ sec. 19. Oil wells.
  E. ½ sec. 27. Eight oil and five gas wells.
  SW. ¼ SW. ¼ sec. 27. Oil well.
  SE. ¼ SE. ¼ sec. 28. Two oil wells.
  NE. ¼ NE. ¼ sec. 33. Two oil wells.
  NW. ¼ NW. ¼ sec. 34. Three oil wells.
  SW. ¼ NW. ¼ and NW. ¼ SW. ¼ sec. 35. Two oil wells.
  NE. ¼ NW. ¼ NW. ¼ SE. ¼ sec. 31. Two oil wells.
T. 6 N., R. 16 W.:
  SE. ¼ SE. ¼ sec. 10. Two oil wells.
  NW. ¼ SW. ¼ and SE. ¼ sec. 7. Six oil and three gas wells.
T. 6 N., R. 17 W.:
  NE. ¼ SW. ¼ sec. 1. Oil well.
  NE. ¼ sec. 12. Three gas wells and one oil well.

ANTICLINES IN THE CLINTON SAND NEAR WOOSTER, WAYNE COUNTY, OHIO.

By C. A. Bonine.

INTRODUCTION.

The " Clinton " formation on the eastern flank of the Cincinnati anticline crops out in a narrow band extending in a north-south direction across Ohio and dips to the east under the great Appalachian coal basin. It has generally been assumed that the eastward dip is fairly regular and that where oil and gas pools have been found in the Clinton sand they are due to arrested dips or terrace structure, a structure that has been regarded widely in the State as particularly favorable for the accumulation of oil and gas since Orton's demonstration that it is the prevailing type in the Lima field.

Although some geologists engaged in private work state that they have mapped local anticlines and synclines in the Clinton sand and have found these folds to be the cause of the pools of oil and gas, very few such data have been published. It is therefore a common belief, especially in the northern part of the State, that no very definite relation exists between such folds and pools of oil and gas.

The Wooster oil and gas field was examined by the writer to determine, if possible, whether there is such a relation and, if not, to find what condition determined the location of the pools. The conclusion reached, after a detailed examination of the field, is that the accumulation of the oil and gas has been largely controlled by geologic structure. The gas occurs along the crest and sides of a sharply folded anticline pitching to the southeast and is confined entirely to the fold. Small quantities of oil are found along the flanks of the anticline, and a fairly large pool of oil occurs close to it, southeast of the gas field. It does not necessarily follow from these conclusions that all the Clinton gas or oil pools are due to the influence of anticlinal structure, but it establishes the fact that some of them are. A more definite knowledge of the structure should aid in the selection of locations for drilling.

Thanks are due to the Ohio Fuel & Supply Co. for well logs furnished and for the location of more than half of the wells shown on the accompanying map; Mr. W. M. Holland, of the Ohio Oil Co., and Mr. James Burtner, of the Columbia Chemical Co., for well logs and general information; to Mr. B. K. Maitland for well logs; to Mr. H. B. Odenkirk for drill samples; and to many other companies and persons for assistance.

LOCATION AND SURFACE FEATURES.

The Wooster oil and gas field lies in northeastern Ohio, in the western and southern parts of Wayne County. Wooster, the largest town in the area, has a population of approximately 6,500 persons. It is on the Fort Wayne division of the Pennsylvania Railroad and the Millersburg branch of the Baltimore & Ohio Railroad.

The stream valleys in the vicinity of Wooster are generally steep sided and in places thickly wooded, but the slopes of the upland are more gentle and have been mostly cleared of timber and put under cultivation. Killbuck Creek, which is the major stream in this region, flows in a southerly direction. It occupies a valley averaging a mile in width, with steep sides but a floor so flat that in places it is swampy. Apple Creek, its main tributary, joins it a little south of the town of Wooster after a circuitous course through the country to the east. The surface relief along this stream is not so pronounced and the valley floor is not so wide as along Killbuck Creek. The many smaller streams which flow into Killbuck Creek from the east and the west have generally steep-sided narrow valleys covered with timber. The elevation of the valley of Killbuck Creek ranges from about 880 feet above sea level northwest of Wooster to about 840 feet at the southern boundary of the area considered. The highest point in the region is Munser Knob, which has an elevation of about 1,280 feet. It is 4 miles east of Shreve and 1 mile east of Killbuck Creek, near the southern boundary of the area represented by Plate XIII (p. 96). In the Wooster oil and gas field the difference in elevation of the creek and the hilltops is about 200 feet.

Four areas of development are included in this field, three of which yield gas and one oil. The oil pool, one of the few of economic importance yet found in the Clinton sand, is about 2½ miles due south of Wooster. It is, according to present development, about 2 miles long in a northeast-southwest direction and three-quarters of a mile wide at the widest point. The Wooster gas pool lies from 1 to 2 miles south and west of the town. It is approximately 4½ miles in length and half a mile or less in width and is being rapidly extended to the northwest. The Lattasburg gas pool is about 7 miles northwest of the Wooster gas pool. The Shreve gas pool lies about 1 mile east of the town of Shreve and 8 miles southwest of Wooster. It is not yet well defined, as drilling began very recently.

HISTORY AND DEVELOPMENT.

The first well drilled to the Clinton sand in the vicinity of Wooster is on the Quimby Jones farm, in the west edge of the town, near the point where the Baltimore & Ohio Railroad track crosses the Lincoln Highway. In this well, which was completed in May, 1910, by Barnhart & Maitland, a small show of oil and gas was obtained. In the following summer another well was drilled by the same company on the McSweeney farm, three-quarters of a mile north of the Jones well. This well is reported to have produced 2,500,000 cubic feet of gas in 24 hours, but the supply rapidly diminished, and water leaking through the casing drowned the gas. On September 10, 1911, the well of the Columbia Chemical Co., on the John Rockey farm, 2½ miles south of Wooster, was completed. Its initial production was at the rate of 2,500,000 cubic feet in 24 hours in open flow, with a rock pressure of 1,025 pounds to the square inch. Encouraged by this showing, the company drilled its next well on the Charles Correll farm, about half a mile east of the Rockey well. A 60-barrel oil well was the result. Drilling for oil was greatly stimulated by this discovery, and the oil field, as now defined, was rapidly developed. Fifty-four producing wells and eight dry holes have resulted from this drilling. The largest initial production was 175 barrels for the first 24 hours from the Albright No. 4 well. At present the daily production averages six barrels to the well. The Frank No. 3 well is the latest addition to the field and is producing 40 barrels a day.

The demand for gas being greater than for oil, drilling for gas was begun in the fall of 1913 by the Arco Oil Co. on the Edward Adair farm, 2 miles southwest of Wooster. The well was completed in October and a flow of 10,000,000 cubic feet of gas was obtained. After this remarkable showing, Murphy Bros. drilled five holes on the Charles Munsen farm. All were good producers, the initial production of the smallest well being about 6,000,000 cubic feet in 24 hours and that of the largest 12,000,000 cubic feet. Forty-three producing gas wells, several dry holes, and a few small oil and gas wells have been drilled in a strip of country 4 miles long and half a mile wide since the discovery of gas in the Adair well in 1913. At present this field is being rapidly extended to the northwest, and many wells are being drilled in adjacent untested territory.

The gas wells in this field do not maintain their initial daily capacity for any great length of time but rapidly diminish in volume and pressure. Wells drilled about 18 months ago, which had an initial production of 5,000,000 to 15,000,000 cubic feet a day and a rock pressure of 1,025 pounds to the square inch, are now producing at the rate of 500,000 cubic feet open flow with a rock pressure of 180 pounds.

FIELD WORK.

The examination made by the writer was begun in December, 1914, but owing to adverse weather only a few days were spent in the field at this time. The work was completed in the later part of April, 1915. As the object of the study was to determine the structure of the Clinton sand with respect to sea level as a datum plane, most of the time was spent in running spirit-level lines from United States Geological Survey bench marks to the mouths of wells and in collecting well records.

No attempt was made to map or study the surface rocks of the area, because the absence of any persistent key rock or stratum, such as a coal bed or limestone outcropping at the surface, the presence of two or possibly more unconformities in the sections of rocks between the Clinton sand and the surface rocks, and the abundant cover of glacial drift render futile any attempt to determine the attitude of the Clinton sand by examination of the exposed rocks.

GEOLOGY.

GENERAL SECTION.

For the information of those not familiar with the geologic formations of Ohio and for convenience in interpreting the well logs of this field, the following table of formations is given:

Generalized section of rocks in the Wooster oil and gas field, Ohio.

System.	Formation.	Driller's name.	Thickness in feet.	Character.
Quaternary (Pleistocene).	Glacial drift.	Sand and gravel.	0-75	Bowlder clay, sand, pebbles, shale fragments, and bowlders.
Carboniferous (Mississippian).	Cuyahoga formation.	(?)	500-650	Dark shales with interbedded sandstones and sandy shales.
	Sunbury shale.			Black argillaceous bituminous shale.
	Berea sandstone.	Berea grit.	30-60	Medium-grained gray to buff-colored sandstone.
Devonian or Carboniferous.	Bedford shale.	Ohio shale.	1,300-1,370	Black and brown carbonaceous shale containing numerous "iron stone" concretions.
Devonian.	Ohio shale group. Cleveland shale.			
	Ohio shale group. Chagrin formation			
	Ohio shale group. Huron shale			
	Olentangy shale.			
	Delaware limestone.	Big lime.[a]	1,030-1,080	Brown, blue, and gray limestones, containing a few thin sandstone and shale beds in the lower portion.
	Columbus limestone.			
Unconformity—— Silurian.	Monroe formation.			
	Niagara limestone.			
	"Clinton" formation.	Little lime probably belongs here.	(?)	Gray or red sandstone and dark shale, with interbedded limestone layers.
		Clinton sand.		
	"Medina" shale.	Medina red rock.	(?)	Red clay shale.

[a] This should not be confused with the Big lime of Pennsylvania, West Virginia, and Kentucky, which is of Carboniferous age.

The rocks exposed at the surface in the Wooster field are dark shale of Mississippian age, with interbedded sandstone and sandy shale. These rocks are for the most part concealed by a mantle of glacial drift, being exposed only where erosion has been active in removing the surficial material.

FORMATIONS.

Well logs.—The character and thickness of the rocks as described by the driller in reaching the Clinton sand are shown in the following well logs, selected from different parts of the field. The descriptions of the rocks are quoted as given by the drillers.

Logs of wells in the Wooster oil and gas field, Ohio.

Charles and J. J. Pressler No. 1 well, drilled by Lupher Drilling & Contracting Co. November 29, 1914.

	Thickness.	Depth.
	Feet.	*Feet.*
Gravel and sand	40	40
Sand and slate	126	166
Slate	334	500
Berea grit	30	530
Slate	1,299	1,829
Lime	1,081	2,910
Salt water in lime		2,061
Slate	50	2,960
Shell	33	2,993
Slate	54	3,047
Clinton sand	32	3,079

Curtis W. Thompson No. 1 well, drilled by Arco Oil Co. April 12, 1914.

	Thickness.	Depth.
Berea grit	60	710
Interval	815	1,525
Little Cinnamon	75	1,600
Interval	100	1,820
Big Cinnamon	120	1,700
Interval	180	2,000
Big lime	1,100	3,100
First salt water in lime		2,260
Salt		2,630
Second salt water in lime		2,920
Interval	30	3,130
Red rock	8	3,130
Interval	22	3,168
Little lime	35	3,195
Interval	18	3,213
Stray sand	1	3,214
Interval	34	3,248
Clinton sand	18	3,266

Charles Correll No. 1 well, drilled by Columbia Chemical Co.

	Thickness.	Depth.
Berea grit	50	580
Interval, slate	1,354	1,934
Big lime	1,021	2,955
Second salt water in Big lime		2,844
Interval	135	3,090
Little lime	33	3,123
Interval	59	3,182
Clinton sand	24	3,206
Total depth		3,218

William T. Stitt No. 1 well, drilled by Lupher Drilling & Contracting Co. March 26, 1914.

	Thickness.	Depth.
Sand and gravel	72	72
Sand and slate	128	200
Interval	440	640
Berea grit	40	680
Slate	1,370	2,050
Lime	1,030	3,080
First salt water in lime		2,290
Second salt water in lime		2,940
Slate	95	3,175
Shell	40	3,215
Slate	105	3,320
Clinton sand	11	3,331
Total depth		3,348

None of the well records obtained were taken with sufficient detail to permit a careful study and correlation of the formations cut by the drill. The drillers have, however, in nearly every log recognized the broader lithologic differences in the strata passed through and have made their records accordingly. The following paragraphs, in which the drillers' terms are used, are intended to give general descriptions of these rocks.

Medina red rock.—The oldest and deepest rock reached in the Wooster field, called Medina red rock by the drillers, is possibly equivalent to the Medina formation of New York. It consists of red clay shale, having in some places a mottled appearance due to the presence of purplish shale layers. None of the well logs record the thickness of this formation, as drilling was stopped when the top was reached.

Clinton sand.—Next above the Medina red rock is the oil and gas bearing formation commonly known as the "Clinton." The drill records show that this formation consists of sandstone and shale, with interbedded calcareous or limestone layers. The principal sand, from which most of the oil and gas is obtained, lies near the base of the formation and is known to the drillers as the Clinton sand. It is in most places a fine-grained compact gray rock, although in some wells a considerable thickness of reddish sandstone is recorded. The thickness of this sandstone in the Wooster field ranges from a few feet to 44 feet, and a few wells report no sand at all. Above this sandstone are several small "stray sands" and limestones, interbedded with dark-gray shale. One or more of these sands is oil bearing in a few localities. "Red rock" is reported in many of the wells a short distance above the Clinton oil sand. This is regarded by the drillers as an indication of the nearness of the sand. It is possibly the same ferruginous material which farther east becomes much thicker and constitutes the Clinton iron-ore bed.

Big lime.—The base of the Big lime in this field is a blue-gray magnesian limestone with several thin layers of shale and sandstone. Considerable quantities of salt water are generally encountered 120 to 130 feet above the base.

The limestone forming the middle portion of the Big lime is blue-gray and brown in color and corresponds in chemical composition to a dolomite—that is, a magnesian limestone. A salt bed 40 feet thick occurs about 600 feet below the top of the Big lime, and salt water is found from 200 to 250 feet below the top. The upper 200 feet of the Big lime is composed of brown and blue granular limestone, which contains interbedded layers of brown calcareous shale near the top.

The Big lime shows a gradual thickening toward the east in the oil and gas fields of northeastern Ohio. Along Lake Erie its thickness increases from 850 feet at Norwalk to 1,470 feet west of Cleveland. In the northeastern part of Cleveland a thickness of 1,720 feet is recorded, but this is probably a local expansion, as the Hermitage well, near Mentor, farther east, shows a thickness of 1,580 feet. A well at Mansfield gives the thickness of the Big lime as 915 feet, and one at Barbertown, 30 miles farther east, shows 1,415 feet. At and north of Wooster considerable irregularity in thickness is shown, and a noticeable thinning of the Big lime toward the east for a distance of about 10 miles is illustrated by the records of a number of wells. Northeast of Jeromeville the Big lime is 1,155 feet thick; farther east, near the edge of the Wooster gas field, it is 1,081 feet; in the Wooster oil field, about 1,030 feet; and north of Mount Eaton, 1,365 feet.

Ohio shale.—Above the Big lime is a mass of black and brown bituminous shale, known to geologists as Olentangy shale, Ohio shale, and Bedford shale. All these formations collectively are known to the driller as Ohio shale. Small quantities of oil and gas have been found in this shale, but not in paying quantities. Like the Big lime, this shale also thickens toward the east, but the increase is more rapid and constant. The well at Mansfield records 700 feet of shale between the Berea sandstone and the Big lime; a well near Hayesville, 13 miles east of Mansfield, 920 feet; the Pressler No. 1 well, 3½ miles west of Wooster, 1,299 feet; the Stitt No. 1 well, 3 miles south of Wooster, 1,370 feet; and the S. P. Beats well, near Mount Eaton, 1,490 feet. This is an increase of 970 feet in about 37 miles, the thickness being more than doubled. At Wooster, where the thickness can be determined in greater detail by reason of the abundance of the wells, there appear to be some irregularities, but the general eastward increase in thickness still holds good.

Berea grit.—The Berea grit is one of the widest-known and best horizon markers in Ohio. Although it generally averages less than 75 feet in thickness, it is a remarkably persistent formation and is used by oil men and geologists as a key for drilling and for the mapping of structure. It is one of the most prolific oil sands in the State, but in the Wooster field has never been found to contain oil or gas in paying quantities. Salt water occurs abundantly in the Berea at Wooster and is always cased off in drilling. This formation is a medium-grained gray to buff-colored sandstone having a tendency to break into slabs. In the Wooster field it ranges from 30 to 60 feet in thickness.

From the Berea grit to the surface in this vicinity the drill encounters a series of black and blue shales and gray sandstones of Mississippian age, about which the well records obtained give no information. The thickness of these rocks from the top of the Berea to the surface, including a cover of glacial material, varies from 500 to 650 feet, depending on the location of the well.

STRUCTURE.

Sedimentary rocks as originally deposited on the floor of the sea are essentially horizontal or nearly so. The modification of the original attitude of these rocks by earth movements produces geologic structure of various types. An upward fold or arch is called an anticline, and a downward fold or trough a syncline. Where rocks have been so tilted as to cause them to dip in one direction only, the resulting feature is called a monocline. Any condition tending to arrest this monocline produces a structural terrace or flattening of the rocks. The axis of a fold is the line marking the highest points of an anticline or the lowest points of a syncline. Structure contours are lines represented as drawn through points, on the top or bottom of a stratum of rock, that have the same elevation above or below a given horizontal plane, generally sea level.

The Wooster oil and gas field is situated along the northern part of the eastern flank of the Cincinnati anticline and is a little west of the outcrop of the Pottsville and Allegheny formations, which mark the northwestern limit of the great Appalachian coal basin. The surface rocks and those cut by the drill have a general dip to the east and southeast of about 50 feet to the mile. This dip has been flattened in many places, producing structural terraces. Cross folding of a more or less intense character has likewise taken place, producing anticlinal and synclinal folds at right angles to the strike of the formations. These folds are especially pronounced in the Clinton sand and exist in a modified form in the Berea sandstone. The surface rocks near Wooster are not well exposed, and consequently it is difficult, if not impossible, to determine whether or not they are similar in structure.

The principal structural feature of the gas field, as shown by the 10-foot structure contours drawn on top of the Clinton sand on Plate XIII, is the sharp, steeply pitching anticline west and southwest of Wooster, along the crest and sides of which the gas has accumulated. The narrowness of the gas-producing area is due to the sharpness of this fold, and the presence of dry holes in close proximity to large gas wells is also partly explained by this fact. Although reported as dry holes, some of these wells produced gas, but not in paying quantities. As far as the anticline has been followed toward the northwest there is no indication of its diminution, but its form and position in this area can be told positively only by more drilling in secs. 1, 2, and 12 of Plain Township. There seem to be two possibilities—either that the Wooster anticline extends northwestward in untested territory, as indicated on Plate XIII by the broken axial line, or that the anticline dies down suddenly and possibly breaks up into a number of minor wrinkles. According to the first hypothesis, the small fold in sec. 36, Chester Township, would be a secondary wrinkle on the flank of the major anticline. Similar structure is suggested in secs. 5 and 6 of Wooster Township by several dry holes, small gas wells, and an oil well.

On the second hypothesis the axial line would follow the most pronounced of the smaller folds, which might be the one to the north shown on Plate XIII. The first hypothesis seems the more plausible, but the second must be regarded as a possibility, even though it involves possibly a curving fold. If these cross folds are due to torsional stresses in the rocks, curved axial lines are not improbable, and long, straight folds are hardly to be expected.

Not enough drilling has been done in the vicinity of Lattasburg, which is about 8 miles northwest of Wooster, to enable the geologist to determine the details of structure. The altitude of the sand in the wells shows that there is only a very slight dip to the east or southeast and suggests a fairly broad, level structural terrace. Although it is a common belief in the field that the Wooster anticline continues indefinitely toward the northwest and serves to connect the Lattasburg and Wooster gas fields, the lack of such a connection is indicated by the drilling done in the area between these fields, because of the discordant altitude of the sand and the nonproductiveness of the wells. On the other hand, the Lattasburg pool is certainly connected with the Ashland field to the southwest.

The structure of the sand in the Shreve gas pool could not be determined, owing to the small number of wells drilled. There are, however, indications of an anticline, for the altitude of the sand, as reported in the well logs from this field, is about 100 feet higher than the normal position of the sand as determined by contouring the Clinton sand in a broad way over a large area in this part of the State.

The structure contours in the oil field south of Wooster show several small, irregular folds in which oil has accumulated and a small but higher structural terrace along the western edge of the field, where gas has collected. From the data at hand no certain prediction can be made as to the structure north of the oil field and east of the main gas field. The anticline of the gas field is evidently flatter toward the east, and it is probable that this disturbed condition of the sand continues some distance in that direction, but whether it continues for 1 mile or 4 miles can not be told until some drilling is done north of the oil field.

U.S. GEOLOGIC
GEORGE OTIS S
R. 15 W.
36
T. 23 N.
1840
T. 22 N.
1860
1880
12
13
24
25
36
T. 22 N.
T. 21 N.
1
LINE
12
13
BOUNDARY
2000
24
40°
45'
25
36
T. 21 N.
T. 20 N.
1
ASHLAND CO
WAYNE CO
12
13
1800
24
R. 15 W.

SUGGESTIONS FOR PROSPECTING.

It is in general very difficult if not impossible to determine the character and position of folds in the Clinton sand from a study of the surface rocks in northern Ohio. However, after considerable drilling has been done it may be possible to outline, at least in part, the anticlines, synclines, and structural terraces and thus to predict, so far as geologic structure controls the accumulation of oil and gas, the most favorable territory for future drilling. This does not apply to new pools, but merely to the extension of known pools into new territory.

The most promising area for the location of gas wells is along the supposed northwestward extension of the Wooster anticline in secs. 1 and 2, Plain Township, but it must be clearly understood that the extension of the axis of this anticline is hypothetical and, even if it extends into this new territory, its exact location can not now be determined. No one should be encouraged to make such a test unless he has the capital and can afford to take what may be considered almost even chances of success or failure.

No prediction can be made as to the extension of the gas field toward Lattasburg. The evidence in this vicinity gives no basis for the assumption that the Wooster "gas streak" connects with the one at Lattasburg, as most of the operators believe. The existence of gas in the Hileman well, in sec. 17, Chester Township, about half way between these pools, does not prove this point, for the well is only a small producer, and similar amounts of gas may be struck at any place in the region.

The finding of dry holes along the northern margin of the oil field in secs. 16, 21, and 22, Wayne Township, has discouraged drilling between that field and Wooster. From the Leisle dry hole, in the NW. ¼ sec. 22, Wayne Township, in which only 3 feet of sand was reported, it seems probable that the lack of oil is due to an area of thin sand, but as the Clinton sand is generally present wherever the drill has penetrated to its depth, it seems probable that the area of thin sand south of Wooster is a local feature and may extend for less than a mile in any direction. If, therefore, it is assumed that there is a possibility of thick sand north of the present oil field, it is probable that the structure is such as to warrant further prospecting. Unfortunately, in the light of present knowledge, this assumption can not be verified until more drilling has been done. The writer is of the opinion, however, that the probability of the eastward extension of the Wooster anticline is sufficiently strong to justify drilling in new territory in sec. 15, Wooster Township.

As some oil has already been found on the flank of the Wooster anticline, the chances for finding more oil along the flanks of the fold to the northwest seem fair and worth considering, though not as good as they are south of Wooster.

Wherever dry holes are encountered the sand is either thin or "broken," or the location has been chosen in a structurally unfavorable place. There seems to be no danger of striking salt water in low places in this field. Water has been reported in several wells in the Clinton sand and at Wooster, but on the whole the sand is considered to be "dry" by the drillers. Water thus reported is assumed to have leaked through the casing from some higher bed.

A significant conclusion to be drawn from the presence of the Wooster anticline in northern Ohio is that the Clinton sand has been subjected to forces tending to produce sharply accentuated folds in a direction at right angles to the normal strike of the beds. Such folds are shown by this investigation to be favorable for the accumulation of oil and gas in this field, and it is safe to assume that other folds of like character occur in this general region. Their presence can be proved only by drilling. Wells drilled to the Berea sandstone only may aid in the determination of structure in the Clinton sand, for both the Berea and Clinton sands, as well as the intervening strata, have been without much doubt subjected to the same deformative forces.

In prospecting east of Wooster much deeper wells will be needed to reach the Clinton sand, for the general eastward dip will be accentuated by the thickening of the overlying formation in that direction.

THE OROFINO COAL FIELD, CLEARWATER, LEWIS, AND IDAHO COUNTIES, IDAHO.

By CHARLES T. LUPTON.

INTRODUCTION.

As reports of the presence of valuable coal in the vicinity of Orofino, Idaho, have been circulated from time to time, the writer made a hasty examination of the field in July and August, 1913. Although no samples could be procured for analysis, the examination showed the coal to be subbituminous coal of medium grade. It is believed to be similar to the coal found at Horseshoe Bend and Jerusalem Valley, Boise County, described by Bowen.[1] Considering the character of the coal and the thinness of the beds, it is believed that this locality will not be of importance as a coal field, except possibly in a small way by furnishing coal for local use in the distant future, when timber becomes scarce.

GENERAL FEATURES OF THE FIELD.

The area represented on figure 8 is situated in northwestern Idaho (see fig. 7) along Clearwater River and Orofino Creek, 30 to 55 miles east of Lewistown, and contains about 150 square miles. The area mapped includes all of T. 36 N., Rs. 2 and 3 E., and parts of T. 35 N., Rs. 1, 2, and 3 E., T. 36 N., Rs. 1 and 4 E., and T. 37 N., Rs. 1, 2, 3, and 4 E., Boise meridian. The western part of this area was formerly included in the Nez Perce Indian Reservation.

Orofino, a town of about 500 inhabitants, is the principal settlement in the field. It is at the mouth of Orofino Creek, on the north side of Clearwater River, on a branch of the Northern Pacific Railway, which crosses the field in a northwesterly direction. Ahsahka, at the junction of the two forks of Clearwater River, and Greer, on the South Fork of this stream, in T. 35 N., R. 2 E., are smaller railway towns. Russell and Fraser are but little more than post offices situated at ranches.

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[1] Bowen, C. F., Coal at Horseshoe Bend and Jerusalem Valley, Boise County, Idaho: U. S. Geol. Survey Bull. 531, pp. 245–251, 1911.

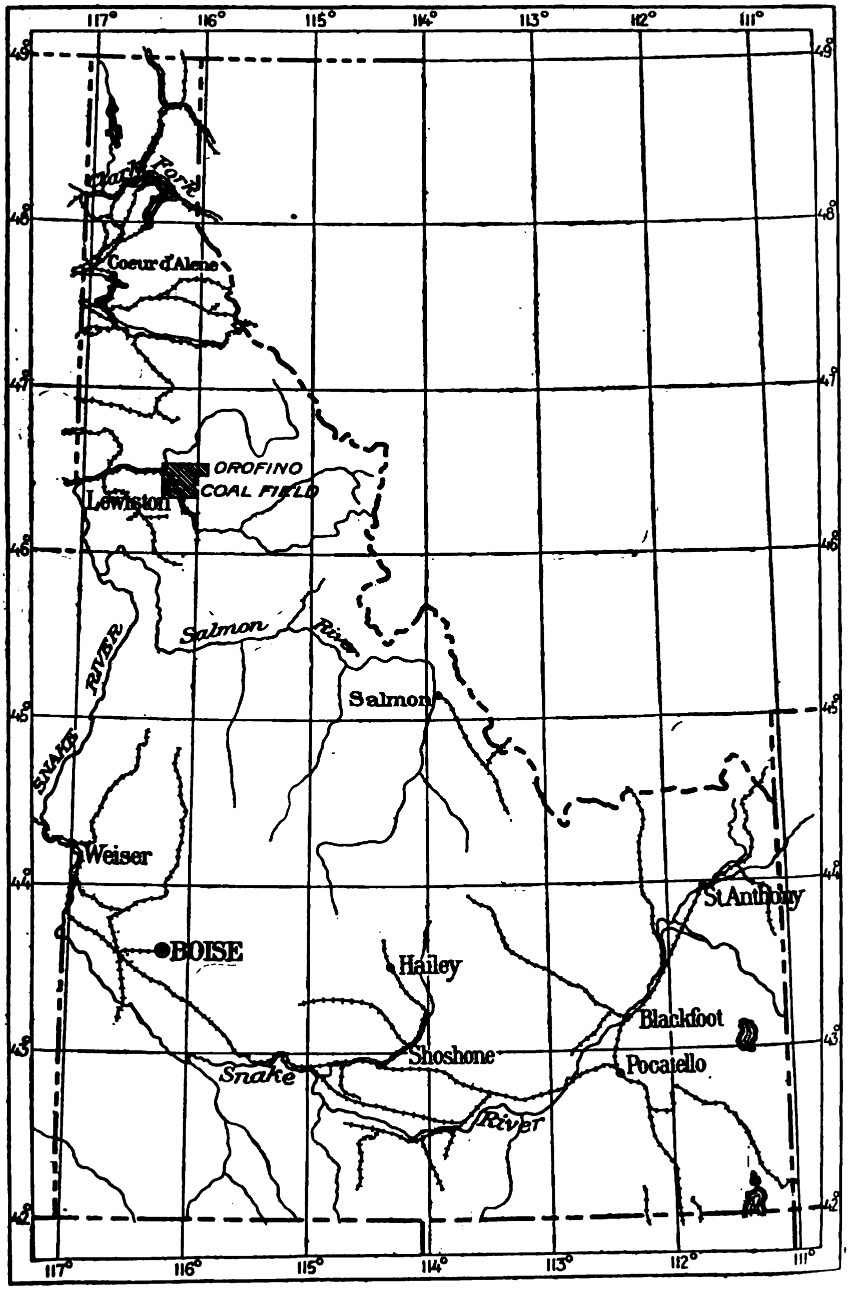

FIGURE 7.—Map of Idaho showing location of Orofino coal field.

A fairly good wagon road follows Clearwater River from the west edge of the field to Orofino. Another road leads from Orofino along the north side of Orofino Creek to the mouth of Whisky Creek, and thence to the top of the divide between Whisky and Orofino creeks, which it follows to the east. A much-used road extends up Whisky Creek and over the divide to North Fork. Other roads and trails exist in the area, but the writer knows little regarding them.

The surface of the area represented on figure 8 is hilly to mountainous, the altitude above sea level ranging from a little less than 1,000 feet, near Ahsahka, to slightly more than 2,000 feet on the uplands in the eastern part of the field. The valleys, including that of Clearwater River, are comparatively narrow and canyon-like and contain remnants of terraces. In many places the stream valleys have nearly vertical walls, due to the recent cutting of these streams into the Columbia River basalt, which constitutes the surface rock of most of this area. The uplands are comparatively flat and smooth, many parts of their surfaces representing the top of the great flows of lava that in Tertiary time spread over this region.

The original topography has been modified in many places in the valleys of the larger streams by landslides, regarding which Russell[1] makes the following statement:

> In the description of the occurrence of lignite and its associated sedimentary beds near Orofino and along the creek of the same name mention was made of the numerous displaced rock masses of that region. The borders of the canyon of Orofino Creek not only owe the minor features of their topography to landslides, but the character of the entire canyon has been modified by them. There is an outer canyon, bordered by cliffs and steep talus slopes, from 700 to 800 feet high. At the base of these rugged walls, in which the edges of horizontal sheets of lava appear, there is on each side of the creek an irregular terrace-like belt a mile or more wide, the surface of which shows the ridges, hills, and basins characteristic of landslide topography. This broken country is from 400 to 500 feet above the stream, which flows through it in a steep-sided inner canyon. At a few localities the landslides have obstructed the river and caused it to flow swiftly through narrow defiles.

GEOLOGY.

The geologic work of Lindgren and Russell was much more comprehensive and detailed than that done by the writer; hence this paper contributes little new geologic information. It contains, however, a compilation of the available data regarding the Orofino coal that may be of service to those interested in its development. Lindgren[2] reports "quartzites, sandstones, conglomerates,

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[1] Russell, I. C., Geology and water resources of Nez Perce County, Idaho: U. S. Geol. Survey Water-Supply Paper 53, p. 78, 1901.

[2] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U. S. Geol. Survey Prof. Paper 27, p. 17, 1904.

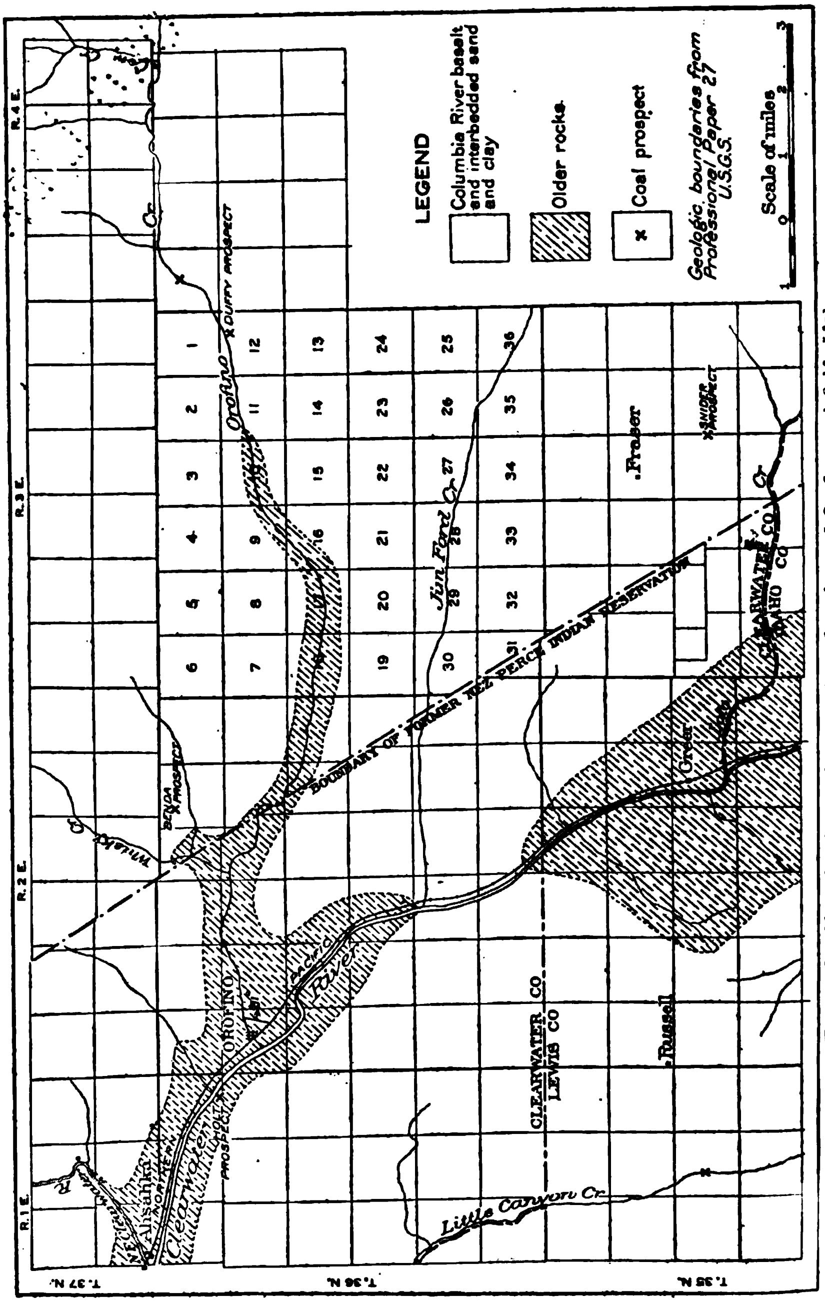

FIGURE 8.—Map showing coal prospects and geology of Orofino coal field, Idaho.

limestones, and shales, as well as large masses of associated old and partly altered and schistose lavas (greenstones)" near Ahsahka, at the mouth of the North Fork of Clearwater River. He says, "The structure of this series is little known except that the dips are generally steep and the strike has a general northerly direction. At Orofino, North Fork, and Pierce are gneisses, mica schists, and occasional crystalline limestones bordering the intrusive granite of the Clearwater Mountains. These are partly at least of sedimentary origin, but their age is unknown." The present writer observed limestone and schist dipping 70°–85° E. and in places striking slightly east of north near water level along Clearwater River from a point a few miles west of Peck (a town about 5 miles west of Ahsahka) to the vicinity of Greer. At Orofino crystalline limestone is well exposed on the north side of the river and is quarried for the manufacture of cement. The beds in the quarry dip 81° E. and strike about N. 10° E. and are somewhat broken by minor faults, as shown in part by slickensided surfaces. These rocks have been referred to by Russell[1] as the "older group, of both igneous and sedimentary origin." He says also, "The younger group consists principally of basalt but includes layers of clay, sand, gravel, volcanic dust, and lapilli interbedded with it." It "contains lignite which may prove of value and on decomposing furnishes a deep, rich, dark soil of marvelous fertility." This series of lava flows is known as the Columbia River basalt, which, according to Russell,[2] "was outpoured at successive intervals embracing a long period of time, as is shown by the occurrence, at several horizons, of layers of sedimentary material, principally clays and sand, between the lava sheets." The coal described below is found in the interbedded sand and clay.

Russell considered the sandstone, shale, and coal beds in the Orofino field to range from 200 to 300 feet in thickness and to occur from about 700 to 1,000 feet below the tops of the uplands. He says:[3]

> Throughout the length of Orofino Creek, from its mouth to near Pierce City, there is an almost continuous series of heavy landslides on each side of the creek, which indicates the presence of incoherent beds at least 200 to 300 feet in thickness, beginning at a depth of about 750 feet below the surface. These strata are probably a continuation of those which have so greatly influenced the topography of the wall of Clearwater Canyon near Kamiah and elsewhere. Their character is shown by outcrops of sandstone and shale-carrying lignite, which are exposed in the bed of the creek at several localities.

Similar beds of sandstone, shale, and coal are believed to be present along Little Canyon Creek 8 to 12 miles south and southwest of Orofino, just outside of the area shown on figure 8.

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[1] Op. cit., p. 15. [2] Idem, p. 29. [3] Idem, p. 39.

The Columbia River basalt and associated coal-bearing rocks are nearly horizontal, except in localities where there has been slumping, as, for example, along Clearwater River and Orofino Creek. Where landslides have occurred the slumped masses are found near the bottom of the valleys, and usually with the beds dipping toward the uplands, from which they have slipped.

THE COAL.

GENERAL CHARACTER.

The coal in the Orofino field, called lignite by Lindgren and Russell, should more properly, to judge from specimens collected by the writer, be designated subbituminous. A hand specimen that had been exposed to weathering at the Duffy prospect on Orofino Creek for 8 or 10 years was probably nearly as firm as when it came from the prospect. This fact suggests that the coal has good "stocking" qualities. The coal at this prospect is probably of higher rank than the greater part of the "lignite" referred to by Lindgren and Russell. Russell[1] suggests this in the following statement:

> Small specimens of lignite "float," said to have been found in the canyon of the North Fork of Clearwater River in the vicinity of Elk Creek, and other similar fragments from Orofino Creek, are jet-black in color and evidently are of much better quality than any of the material thus far obtained at the localities described.

Very little prospecting has been done in this field recently, and the prospects opened several years ago have caved so that it was impossible to enter them. At only one place (Benda's prospect) was it possible to see the carbonaceous material in place, and here it is of no economic importance. For this reason the greater part of the information collected by the writer was obtained from settlers and others who knew something of the old prospecting.

The sample collected from the Duffy prospect is jet black, mostly dull, but having a few bright lustrous layers. Woody structure is evident in parts of the sample, and as a whole it is laminated, showing thin plates ranging from films to bands a quarter of an inch in thickness. The fracture is irregular, and the jointing is somewhat columnar. Considerable resin in globules as much as one-third of an inch in diameter occurs along the bedding planes of the coal. The coal is hard, and when pulverized is a black powder, with a slightly brownish tint.

No samples of the coal for analysis were collected by the writer, because it was impossible to find prospects or outcrops where the coal was unweathered.

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[1] U. S. Geol. Survey Water-Supply Paper 54, p. 127, 1901.

Russell[1] gives the following analyses of samples collected by E. W. Barnes, of Portland, Oreg., from the same formation on Grande Ronde River, Wash. These analyses do not give the heat units, and furnish only an approximate idea of the composition of the coal.

Analyses of lignite from Grande Ronde River, Wash.

[Analyst, J. T. Gove.]

	1	2
	Per cent.	*Per cent.*
Moisture	20.50	6.50
Volatile matter	40.75	38.50
Fixed carbon	31.25	42.00
Ash	7.50	13.00
	100.00	100.00

It is believed that the poorer grade of coal (lignite) in the Orofino field is similar in chemical composition to that represented by these analyses. The better coal, like that at the Duffy prospect, on Orofino Creek, is probably similar to the coal near Horseshoe Bend, Idaho,[2] the analysis of which is given below.

Analysis of coal sample from the Henry mine, Horseshoe Bend, Idaho.

[Bureau of Mines laboratory, A. C. Fieldner, chemist in charge. Laboratory No. 12703. Air-drying loss, 5.4 per cent.]

	As received.	Air-dried.
	Per cent.	*Per cent.*
Moisture	10.1	5.0
Volatile matter	38.2	40.4
Fixed carbon	36.1	38.1
Ash	15.6	16.5
Sulphur	.51	.54
British thermal units	10,440	11,030

PROSPECTS.

Duffy prospect.—The Duffy prospect, on the south side of Orofino Creek, in the NE. ¼ sec. 12, T. 36 N., R. 3 E., 10 or 12 miles from Orofino, was visited by the writer. As the shaft was nearly full of water, it was impossible to see the coal in place. This prospect, it is reported, was opened by Tom Duffy and three other prospectors about 1903. The shaft, whose mouth is only a few feet above the creek, is said to be 30 or 40 feet deep. From the bottom of the shaft an entry was driven about 70 feet. Coal in this entry is reported to range from 30 to 36 inches in thickness and to occur in three benches, none of which is more than 12 inches thick. The bed is believed to be nearly horizontal, with possibly a slight dip away from the stream.

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[1] Op. cit., p. 126.

[2] Bowen, C. F., Coal at Horseshoe Bend and Jerusalem Valley, Boise County, Idaho: U. S. Geol. Survey Bull. 531, p. 251, 1911.

No exposures of the sedimentary strata were observed at this place, as the basalt extends down almost to the level of the stream. Apparently the shaft and outfit, consisting of a small cabin, a windlass, diamond drill, and water wheel for pumping water from the shaft, have long been abandoned. Fragments of coal found near the shaft mouth indicate that this coal is of higher grade than lignite. Those who have used it report that it burns like poor pine wood and yields considerable ash.

Other prospects on Orofino Creek.—Another old prospect is reported about a mile east of the Duffy prospect, approximately in sec. 6, T. 36 N., R. 4 E. This prospect is said to consist of a shaft 30 to 50 feet deep, in the bottom of which a diamond drill was sunk in search of lower coal beds. The coal encountered in the shaft is reported to be not so thick as the bed at the Duffy prospect. No coal was sold from either of these prospects, the opening of which, it is estimated, cost from $15,000 to $20,000 in labor and machinery, all material having been brought in by means of a pack train from Orofino over a very poor trail which crosses the divide between Orofino and Whisky creeks. This divide is at least 1,500 feet high.

Russell[1] reports a prospect farther east on Orofino Creek, which he visited in 1899, as occurring in sec. 12, T. 36 N., R. 4 E. It is believed, however, that the location may be near the Duffy prospect in T. 36 N., R. 3 E. Regarding the coal or "lignite" in this locality he makes the following statement:

> Lignite is reported to occur at several localities on Orofino Creek (all of it probably belonging to approximately the same bed), within a distance of several miles in the middle portion of its course. The only one of these outcrops that was examined by the writer is situated on the immediate banks and in the bed of the creek about 15 miles above its mouth (sec. 12, T. 36, R. 4) but is not in place. * * * On the left bank of the creek, at the locality referred to, and partially submerged, the following section is exposed, the dip being south at an angle of 30° and the strike about east-west, or with the course of the stream.
>
> *Section on Orofino Creek about 15 miles above mouth.*
>
> | | Inches. |
> |---|---|
> | Sandstone, gray, with fossil leaves | 12.0 |
> | Lignite | 20.0 |
> | Clay parting | 2.5 |
> | Sandstone, base not exposed | 6.0 |
>
> These outcrops can be followed along the bank of the creek and in its bottom for a distance of 60 to 70 feet. Near the upstream end of this natural exposure, on the north side of the creek and at the water's edge during low-water stages, a prospect shaft about 15 feet deep has been opened. In this shaft the strata where first met, beneath a foot or two of surface débris, are nearly vertical, but below they dip northward and soon flatten, until the inclination is about 50°. The lignite is 27 inches thick and has fine micaceous clay on its southern side and a coarse sandstone on its northern side. The lignite-bearing formation on

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[1] Op. cit., p. 123.

the two sides of the creek is a portion of a sharp upward fold or anticline, which is broken along its crest, where the creek flows. This fold is obviously due to the weight of the landslides on each side, and is not a structural feature of the beds in place. The true position of the lignite in the canyon walls is not known but should be looked for at an elevation of between 400 and 600 feet above the creek.

Benda prospect.—A little prospecting was done in 1909 and 1910 in the NW. ¼ sec. 2, T. 36 N., R. 2 E., on Frank Benda's homestead, which is about 4½ miles northeast of Orofino. The prospect is about 500 feet above the bed of Deer Creek and at about the horizon suggested by Russell as the stratigraphic position of the lignite beds at the easternmost prospect on Orofino Creek. The material discovered at this place by Mr. Benda is not coal, however, but a form of basalt containing some carbonaceous material that will burn slightly when ignited. It is of no known economic importance.

Holt prospect.—A prospect for coal was opened about 1901 on the James Holt homestead, on the south side of Clearwater River, in the S. ½ sec. 1, T. 36 N., R. 1 E., about three-fourths of a mile west of Orofino station. One of the men who helped to open this prospect (now caved) stated that in a 10-foot drift a 3-inch bed of brownish-black shaly coal or lignite was discovered. This material would burn when mixed with good coal, but contained so much ash that it retained its shape after burning.

This prospect is undoubtedly near the one referred to by Russell[1] in the following statement:

> On the southern side of Clearwater River, a half mile below Orofino, openings have been made in the side of the canyon, on the farm of F. M. Holt, at an elevation of about 200 feet above the river, which reveal the following section:
>
> *Section on Clearwater River one-half mile below Orofino.*
>
> | | Ft. | in. |
> |---|---|---|
> | Talus from slopes above. | | |
> | Sandstone, coarse | 2 | 0 |
> | Slate, fine, sandy | | 10 |
> | Lignite, with branches of trees | | 4 |
> | Sandstone | 2 | 6 |
> | Lignite | | 3½ |
> | Sandstone | 5 | 0 |
> | Lignite | 1 | 8½ |
> | Sandstone, bottom not seen | 1 | 0 |
> | Talus to the river bank. | | |
>
> The beds are well exposed in the openings that have been made, one of them being a tunnel about 40 feet in length, but the material is part of a series of landslides, and the true position of the lignite should be sought about 500 feet higher than where it is now to be seen.

Other exposures on Clearwater River.—The general statement that some coal or lignite is exposed along Clearwater River between Orofino and Peck (about 12 miles west of Orofino) was made by men who had done some prospecting in this locality but was not verified by the writer.

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[1] Op. cit., p. 122.

Snider prospect.—About 1909 a prospect was opened a short distance southeast of Fraser post office, in sec. 14 or 15, T. 35 N., R. 3 E., by Henry Snider. A son of Mr. Snider, who helped to open the prospect (now inaccessible on account of caving), stated to the writer that the coal is very similar to that of the Duffy prospect, that it burns readily and leaves a white ash, and that he saw no evidence of sulphur or resin in it. The coal crops out in the bed of a creek, but was not noted at any other locality. The coal bed is about 2 feet thick and dips slightly to the east. Extensive prospecting showed that the coal bed does not increase in thickness and quality under cover, so the project of opening a mine here was abandoned.

Other exposures.—Coal is reported at several places in Little Canyon 10 to 12 miles south of Orofino. Russell[1] makes the following statement regarding one of these exposures:

> One of these outcrops, near Russell [T. 35 N., R. 1 E.], which was examined by the writer, is at the bottom of the canyon, which there is 800 feet deep and has precipitous walls composed of horizontally bedded lava sheets. * * * The following section was exposed by a recent excavation:
>
> *Section in Little Canyon, near Russell, Idaho.*
>
> | | Ft. | in. |
> |---|---|---|
> | Talus, fallen from above | 6 | 3 |
> | Carbonaceous shale, apparently altered by heat | 3 | 5 |
> | Parting of white laminated shale composed in part of volcanic dust | | 1 |
> | Black carbonaceous shale | | 2½ |
> | White "shale" | | 1½ |
> | Black carbonaceous shale | | 6 |
> | White laminated shale | | 10 |
> | Coarse sandstone with fragments of shale; base not exposed | 3 | 0 |

In this place the strata are well exposed, and the absence of coal indicates that little or none may be expected in this general locality.

CONCLUSIONS.

The inferior quality of the coal and the fact that extensive prospecting in this region has failed to reveal coal in commercial quantities suggest that the field will be of no importance as a producer of coal or lignite except in a very local way. It is questionable if any additional information regarding the coal or lignite possibilities of the general region of sufficient promise to justify further prospecting will be found, and the writer does not advise anyone to expend time and money in such work.

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[1] Op. cit., p. 124.

A RECONNAISSANCE FOR OIL NEAR QUANAH, HARDEMAN COUNTY, TEXAS.

By Carroll H. Wegemann.

INTRODUCTION.

The town of Quanah is situated on the Fort Worth & Denver City Railway, in Hardeman County, Tex., about 90 miles northwest of Wichita Falls and 6 miles south of Red River, which here forms the boundary between Texas and Oklahoma. (See fig. 9.) It is reached also by a branch line of the St. Louis & San Francisco system. The country in the vicinity of Quanah is not a proved oil or gas field, but reports of surface indications of oil and gas in the region have been current for some time. The examination here reported was undertaken in the fall of 1914 to determine if possible the geologic

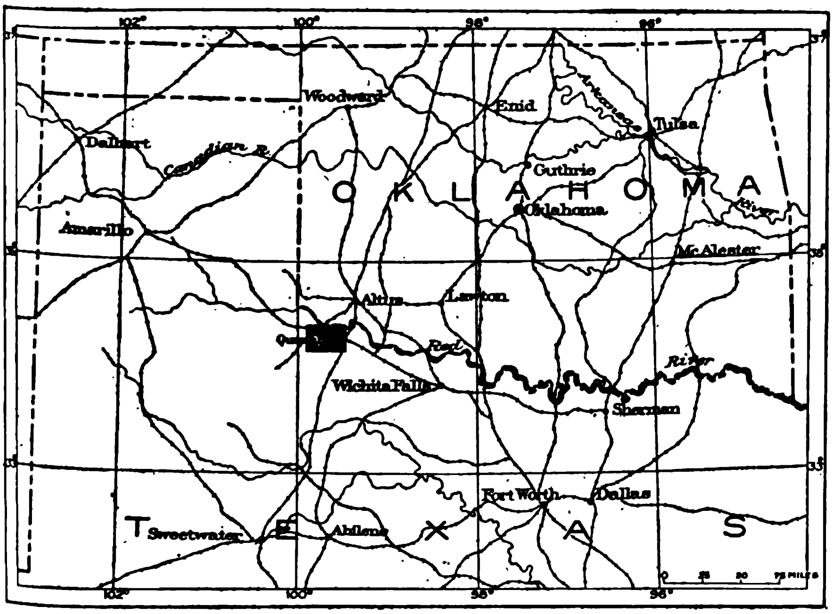

Figure 9.—Index map of Oklahoma and northern Texas, showing location of area near Quanah.

structure of the area and the presence or absence of anticlines which might be effective in producing accumulations of oil or gas.

The writer has been assisted both in the field and in the office by Mr. Ralph W. Howell, of whose able work he desires to express his appreciation. Thanks are due to many residents of the district for courtesies extended during the prosecution of the field work, and particularly to members of the W. A. Doyle Oil Co. for valuable information in regard to the region.

The most noteworthy occurrences of oil near Quanah are those reported from the wells of the American Cement Plaster Co., 1 mile north of Acme, and of the Acme Cement Plaster Co., near Acme station, about 6 miles northwest of Quanah. According to report, the American Cement Plaster Co. sunk a well for water in the engine room of the plant to a depth of 27 feet. The well had a diameter of 11 feet and produced water, oil, and gas. It is said that from 8 to 12 barrels of oil a day was taken from this well for a considerable period and that the oil appeared to flow into the well intermittently. It is also said that the well seemed to be situated on the line of a fault, the strata on one side being displaced with reference to those on the other. Because of difficulty in regard to fire insurance this well was finally closed. A well sunk by the Acme Cement Plaster Co. to a depth of about 70 feet is reported to have yielded warm water and a showing of oil.

About 7 miles northwest of Quanah and 4½ miles north of Acme, in sec. 199, a test well known as the W. A. Doyle No. 1 is now being drilled. In this well a showing of oil is reported. A well sunk for water on the Gardenhauer ranch, in sec. 290, 13 miles west and a little south of Quanah, is said to have given a trace of oil. Other reports of oil and gas seeps are current in the region, but the details of the occurrences were not learned.

TOPOGRAPHY.

Quanah lies in the open plains region of northern Texas. The surface of the country is gently undulating, and rock exposures over much of the area are comparatively few. The area studied lies between Red River on the north and Pease River, a branch of Red River, on the south.

STRATIGRAPHY.

The rocks exposed at the surface in the vicinity of Quanah belong to the Clear Fork formation of the Permian series. The Clear Fork overlies the Wichita formation and, according to Cummins,[1] who originally defined the terms, differs from the Wichita in having a greater number of limestone beds and in containing beds of gypsum.

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[1] Cummins, W. F., Geology of northwest Texas: Texas Geol. Survey Second Ann. Rept., pp. 400 et seq., 1890.

About 11 miles southwest of Quanah and 7 miles south and a little west of Goodlet, in the "breaks" of Pease River, all the strata which reach the surface in the Quanah area are well exposed, the detailed rock section being as follows:

Section at wooded bluff half a mile west of the west line of sec. 287.

[See graphic section on Plate XIV.]

	Ft.	In.
(A) Limestone, coarse grained, soft	5	0
Shale, red and blue	26	0
Gypsum, soft, granular	3	0
Shale, red and blue	25	0
(B) Gypsum, base soft, upper part hard, white	10	0
Limestone, fossiliferous		8
Shale, red at base, gray above	11	0
Gypsum	9	0
Shale, calcareous, gray, containing some thin limestone layers that weather white	6	0
(D) Limestone, hard, light gray, weathering white; prominent over much of field	3	0
Shale, gray and green	5	6
Gypsum, white and blue, hard	9	0
Shale, gray and red	8	0
Limestone, white, fine grained, perforated with innumerable small holes about one-sixteenth of an inch in diameter	4	0
Shale, blue and greenish gray	3	6
(G) Gypsum; soft and granular in lower part; hard, blue, tinted with red, in upper part	21	0
Shale, red	5+	
Base not exposed.		
	154	8+

In the section given above the bed of gypsum 21 feet thick (bed G) appears to be the same as that which is mined at Acme. The 3-foot bed of hard light-gray limestone weathering white (bed D), which lies about 35 feet above the top of the thick gypsum bed, forms the surface rock over much of the area and may be used as a convenient horizon marker in the determination of structure. The 8-inch bed of limestone recorded 30 feet above the white limestone appears in some places to be represented by a bed several feet thick, as if part of the overlying gypsum bed (bed B) were replaced by limestone. The highest limestone bed noted in the section (bed A) is the same as that which caps the line of wooded hills several miles west and southwest of Goodlet.

METHODS OF WORK.

In the prosecution of the field work locations were made an
tudes determined by means of a plane table and telescopic alida
the 3-foot bed of limestone (D in section on p. 111 and Pl. X
which lies about 35 feet above the thick gypsum bed (G) mi
Acme. Where this bed is not exposed or has been removed by er
altitudes were determined on other beds which lie either abo
below it and whose relations to the limestone bed are known.
comparison of these numerous observations of altitude throu
the field it has been possible to determine the localities in whic
limestone bed has been thrown into gentle folds by earth move
and those in which it is undisturbed and comparatively horiz
In other words, it has been possible to distinguish the location o
upfolds or anticlines where such exist which may have influence
accumulation of oil and gas.

On the map which accompanies this report (Pl. XIV) out
are indicated by crosses, the altitude of each outcrop is given a
letter referring to the rock section at the side of the map shows
stratigraphic position of the bed on which the altitude was de
mined. The estimated altitude of the limestone key rock (D) is gi
in parentheses at outcrops in which it is not exposed.

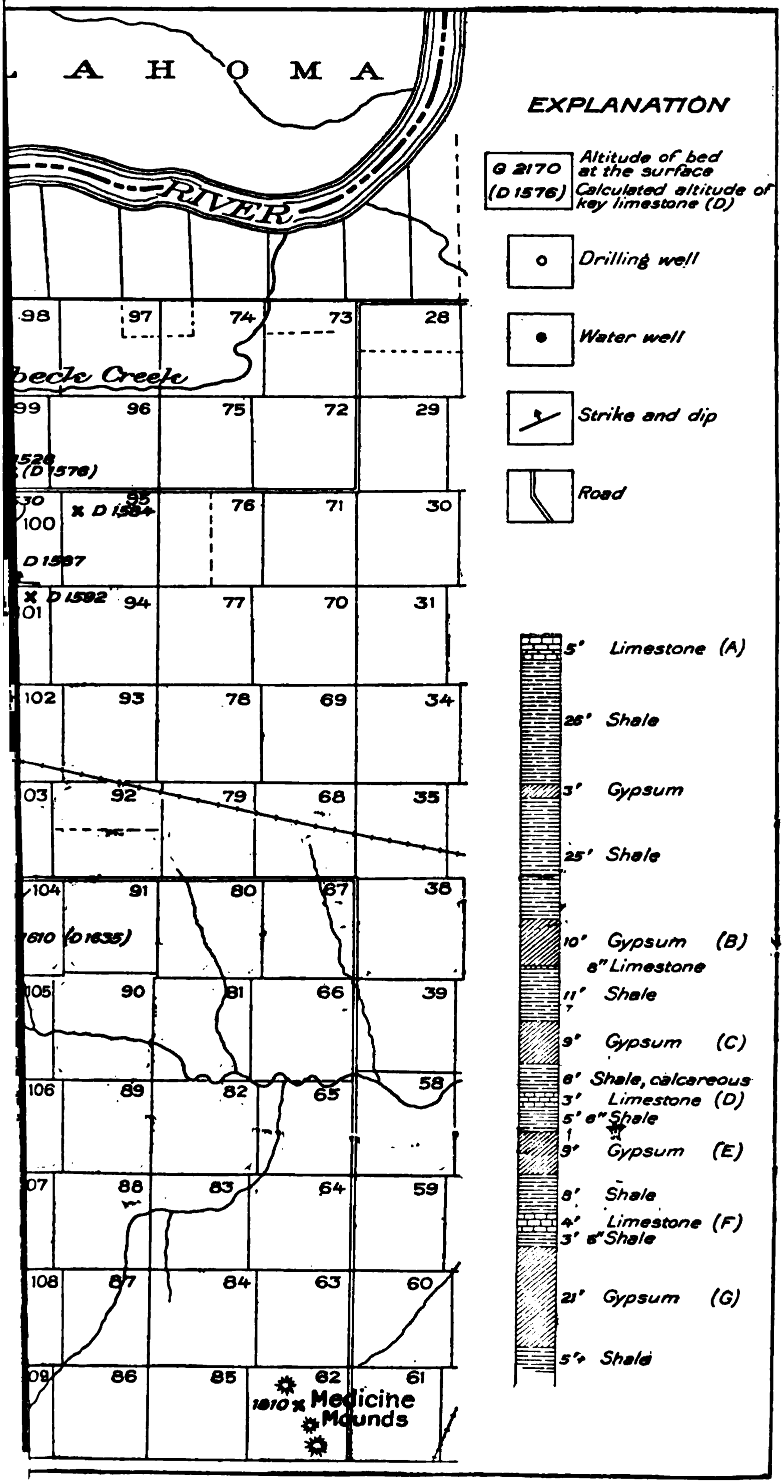
Altitudes in the field were calculated by means of vertical-a
readings and are correct with reference to one another within 5 f
The elevation above sea level as represented by them is not pre
being estimated approximately from railroad profiles.

STRUCTURE.

The prevailing dip of the beds throughout this region is to
northwest, and the angle of dip is comparatively low, in many loc
ties not more than 10 or 20 feet to the mile. The monoclinal str
ture, however, is by no means regular and is interrupted by min
folds or domes which appear to be superimposed upon it.

Southeast of Quanah the dip to the north or northwest is appar
in the difference of 150 feet in the altitudes of the Medicine Moun
and the prominent limestone hill in sec. 104, 5 miles northwest
them. The Medicine Mounds were not visited, but there is litt
doubt that the bed which caps them is very near the horizon of th
which is exposed on the hill in sec. 104 and which caps the line
hills extending northeast from it, if it is not, in fact, the same be

On the south side of Groesbeck Creek, about 4 miles northeast
Quanah, excellent exposures of the limestone and gypsum beds occu
in secs. 95, 99, 100, 101, and 120. In this locality the beds dip to th
north at the rate of about 16 feet to the mile and strike approxi


A H O M A
RIVER
Beck Creek
EXPLANATION
G 2170
(D 1576)
Altitude of bed at the surface
Calculated altitude of key limestone (D)
Drilling well
Water well
Strike and dip
Road
5' Limestone (A)
25' Shale
3' Gypsum
25' Shale
10' Gypsum (B)
8" Limestone
11' Shale
9' Gypsum (C)
6' Shale, calcareous
3' Limestone (D)
5' 6" Shale
9' Gypsum (E)
8' Shale
4' Limestone (F)
3' 6" Shale
21' Gypsum (G)
5' Shale
98
97
74
73
28
99
96
75
72
29
(D 1576)
x D 1584
95
76
71
30
100
D 1587
x D 1592
94
77
70
31
101
102
93
78
69
34
103
92
79
68
35
104
91
80
67
38
1610 (D 1635)
105
90
81
66
39
106
89
82
65
58
107
88
83
64
59
108
87
84
63
60
109
86
85
62
61
1810 x
Medicine Mounds

mately east. The limestone bed (D) is here 60 or 70 feet lower in altitude than on the hill in sec. 104. It is also exposed about 1 mile north of Quanah at the same altitude as in sec. 101. In sec. 140, 1½ miles southeast of Quanah, is a poorly exposed limestone which may represent the same bed (D). If this identification is correct, the strata at this locality occur at about the same altitude as corresponding beds in sec. 104, and the dip to the northwest in that section persists only for a short distance in the direction of sec. 140 or is reversed, forming a very shallow syncline between sec. 140 and sec. 104. Between the exposure in sec. 140 and that mentioned 1 mile north of Quanah there appears to be a dip of 44 feet. In secs. 169, 167, and 194 the limestone (D) is at about the same altitude as in sec. 143, showing that the bed in these and intervening sections is practically horizontal. There is, however, some uncertainty as to the identification of the limestone in sec. 194. The bed there exposed may be a somewhat higher limestone; but if not, there is a slight dip to the northwest, toward Acme. A mile north of Acme, in the NE. ¼ sec. 227, the limestone (D) is at an altitude of 1,577 feet. In the SW. ¼ sec. 206 it is 17 feet lower, and therefore there is little doubt that it dips either to the north or northwest in the vicinity of Acme. At the Doyle well, in sec. 199, a bed of gypsum supposed to be the same as that (G) underlying the limestone is at an altitude of 1,546 feet, and as the limestone (D) is 32 feet higher, were it exposed at this well it would be at an altitude of 1,578 feet, or at about the same altitude as the bed in sec. 227, just north of Acme.

Unfortunately exposures in this locality are so poor and so far separated from one another that exact correlation is very difficult. If the beds at these several localities have been correctly identified, there exists between Acme and the Doyle well (sec. 199) a very shallow syncline, the strata in the vicinity of the well being at least 18 feet higher than those in the axis of the syncline. Beyond the well the beds appear to rise toward the west, for in the NW. ¼ sec. 240 the limestone (D) lies at an altitude of 1,596 feet, or 18 feet higher than it is at the Doyle well. From this outcrop there appears to be a rather pronounced dip to the northeast, and in sec. 232 the limestone is at an altitude of 1,575 feet, or 21 feet lower than the same bed a mile to the southwest. It would appear, therefore, that a small roll or anticline exists in this locality, the axis of which crosses the NE. ¼ sec. 240 and trends in an east or southeast direction toward the Doyle well but pitches in this direction so that the Doyle well is not on the highest part of the fold.

One mile south of Goodlet and 3 miles due west of Acme the limestone (D) is exposed at about the same altitude as in the vicinity of Acme. Six miles due west of Goodlet the highest limestone (A) in the section caps a prominent hill in the SW. ¼ sec. 358, where the strata dip at a low angle to the west. The key limestone (D) is exposed a mile southeast of this locality, in the SE. ¼ sec. 357, where it dips to the east or southeast, or in the opposite direction from the dip in sec. 358. There is, therefore, in the northern part of sec. 357 a small dome or anticline, probably of very slight extent, the axis of which appears to cross the north line of sec. 357 at about its middle point. About 3 miles south of this dome a dip to the north or northwest is apparent between outcrops of the highest limestone bed (A) southeast of Lazare, the strata rising toward the south or southeast in the direction of the prominent hills which cross the southwest corner of sec. 287 and which are capped by this bed. As the dip 3 miles northeast of Lazare is to the southeast or south and the dip southeast of Lazare is to the north or northwest, it is apparent that there is a syncline about 1 mile northeast of Lazare.

POSSIBILITIES OF OIL AND GAS IN THE VICINITY OF QUANAH.

The possibility of finding oil or gas in commercial quantities in the vicinity of Quanah is a subject on which no very definite conclusions can be reached from an examination of the geology of the surface. The rocks of the lower part of the Wichita formation or the upper part of the Cisco formation, from which the oil of the Electra field, 50 miles southeast of Quanah, is derived, doubtless underlie the Quanah area, and there seems no good reason why the sands which are oil bearing at Electra should not contain more or less oil in the vicinity of Quanah. Pronounced domal or anticlinal structure, however, which appears to be, in the oil fields of this general region, one of the controlling factors in the accumulation of oil, is not well developed in the Quanah area. The gentle northwestward dip of the rocks in this region is interrupted by small domes or anticlines, but the efficiency of folds in which the dips are so low in controlling accumulations of oil may be doubted. The question whether oil is present here can be answered only by the drill. The Doyle well, now being drilled 7 miles northwest of Quanah, appears to be near the axis of one of the small folds but rather low on the axis.

A small fold which may be easily recognized from an examination of the surface is situated in sec. 357, 5 miles due west of Goodlet. This may be tested by a well just southeast of the southeast end of the prominent wooded hill in the SW. ¼ sec. 358.

There is a pronounced rise of the beds from the vicinity of Quanah toward the great buttes known as the Medicine Mounds, which are in sec. 62, about 10 miles to the southeast. The area in the vicinity of the mounds was not studied, but if, on detailed examination, a flattening or reversal of dip is found southeast of the mounds, this area may be considered as worthy of a test.

From the lack of surface exposures or of detailed well records in the area between Quanah and the Electra field, it is impossible at the present time to make accurate estimates of the depth at which the oil-bearing rocks in the Electra field may be reached in the Quanah area. The most productive sand in the Electra field is struck at a depth of about 1,000 feet. A rough estimate, which is all that can be made with the information at hand, would place the Electra sands about 1,000 feet deeper at Quanah than at Electra. In other words, the principal producing sand should be encountered at or a little more than 2,000 feet below the surface at Quanah.

"Wildcatting" in an area in which the rock structure is no more pronounced than in the region of Quanah is attended with considerable risk and should be undertaken only by companies that can well afford to take the chance of failure. It is believed that the locations for test wells above outlined are the best in the area examined. If tests in these localities should prove unsuccessful the chances of finding oil in the area would appear to be doubtful.

GEOLOGY AND COAL RESOURCES OF NORTHERN TETON COUNTY, MONTANA.

By EUGENE STEBINGER.

INTRODUCTION.

The paper here presented describes the coal resources of a large area in Teton County,[1] northwestern Montana, including the Blackfeet Indian Reservation and a considerable area of the country lying to the east. The scope of the paper is limited to a consideration only of those features having a bearing on the value and quantity of the coal present. The geology of the region is briefly described, the aim being to give a general understanding of the geologic setting in which the coals occur.

Nearly all the rocks in northern Teton County belong to formations that are of the same age as others which, elsewhere in Montana, contain almost all the coal found in the State. This fact led to several generous estimates as to the extent of the coal-bearing areas likely to be found in this region. Weed[2] and Rowe[3] have published maps on which the valuable bituminous coal area of the Great Falls field is shown as extending northward entirely across Teton County to the Canadian boundary. Similarly, the presence of an extensive coal field, long actively developed at Lethridge, Alberta, 50 miles north of the boundary, gave rise to forecasts that a southward extension of that field, following the strike of the geologic formations, would be found on the line of the Great Northern Railway in northern Teton County. The result of the present work shows that although the coal-bearing formation of the Great Falls field, the Kootenai formation, is present in the area here described, the only coal in it is a bed 6 or 8 inches thick in Marias Pass, also that although the horizon of the coal mined at Lethbridge is traceable entirely across this area, it shows only thin coal beds, nowhere over 18 inches thick. Although outcrops of coal are widely distributed in all parts of the county, the total amount of coal is not large. There are coal beds between 1½ and 3½ feet thick in three districts, comprising only a small percentage of the total area described, but the general scarcity of fuel in the region, together with an increasing population due to the development of extensive irrigation projects, gives considerable importance to these small areas of coal land.

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[1] Since the completion of this report the area in Rs. 3 and 4 W., on the east edge of the region here described, has been included in Toole County, recently established.

[2] Weed, W. H., The coal fields of Montana: Eng. and Min. Jour., vol. 53, p. 521, 1892.

[3] Rowe, J. P., Montana coal and lignite deposits: Univ. Montana Bull. 37, Geol. series No. 2, pl. 2, 1906.

The location and relative extent of the area described in this paper are shown on the index map (fig. 10). The area lies wholly in Teton County, occupying nearly all of its northern half, and contains about 3,100 square miles, of which 2,425 square miles is in the Blackfeet Indian Reservation. The international boundary between Alberta and Montana forms its northern limit, the one hundred and twelfth meridian is the boundary on the east, and the irregular line formed by Marias River and Birch Creek is the boundary on the south. On the west the examination was extended to the limits of the Indian reservation.

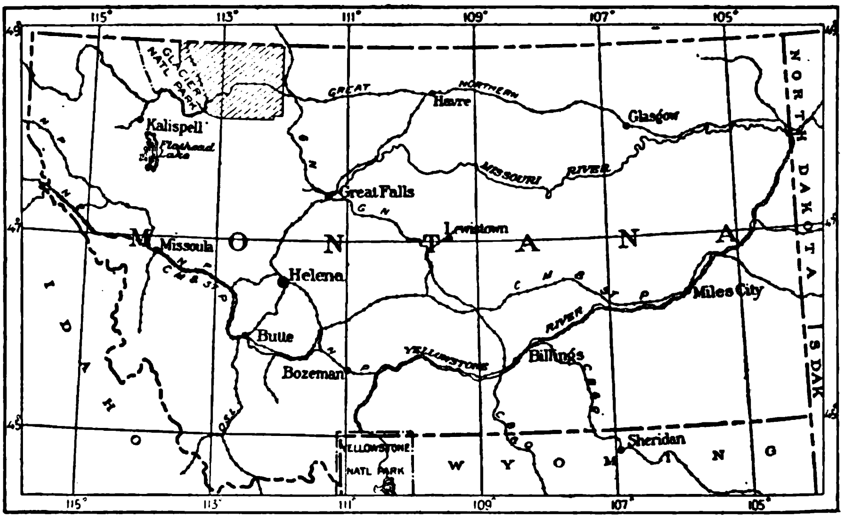

FIGURE 10.—Index map showing location of northern Teton County, Mont. (shaded area).

The county is a gently sloping, nearly treeless plains region that is everywhere easily accessible and offers comparatively few obstacles to railway or road construction. The main line of the Great Northern Railway crosses the region in an east-west direction, and a local line, the Montana Western Railway, extends to Valier, in the southeast corner of the area. Valier is the largest town and is the center of a thriving agricultural community, whose lands are watered by an extensive irrigation project, established under the Carey Act, with headgates on the upper part of Birch Creek. Ethridge, Cut Bank, Browning, and Glacier Park are the principal towns on the Great Northern Railway. Browning is the seat of the Indian agency for the Blackfeet Reservation. The only postal facilities off the railway are at Babb and Family, both of which are served by stage lines running out of Browning. On the Indian reservation settlement so far has been limited almost entirely to its west half, where Indian ranches devoted almost exclusively to the raising of horses and cattle lie along the principal streams. The extensive interstream stretches remain an open range country without fences or other improvements. On the east edge of the reservation the United States Reclamation Service has under construction a system of canals whose waters will irrigate an area of about 300 square miles lying in Tps. 30 to 35 N., Rs. 5 to 7 W. This area should eventually support a large population. The canals will take water from Birch and Cut Bank creeks and all the streams lying between them. The area outside of the reservation is well settled, most of the land having been occupied during the recent movement of settlers to the plains region of Montana, after the development of dry farming.

FIELD WORK.

Classification of the public lands with respect to their mineral value was the immediate object of the work undertaken, and therefore in addition to a regional examination of the geology necessary to an understanding of its broader features the writer made a close inspection of all the mineral-bearing tracts. The accurate location of these tracts with reference to the lines of the General Land Office surveys was also indispensable. The fact that six out of eight of the Cretaceous and Tertiary formations present are likely to be coal bearing, together with the widespread occurrence of coal in thin beds continually suggesting the possibility of the occurrence of thicker coals at a neighboring locality, made necessary a careful search for coal in all parts of the region. Because of the tendency of the soft bedrock formations to erode into badlands wherever the relief is abrupt, the exposures of the formations and coal beds on most steep slopes, and especially along the watercourses, are excellent and the presence or absence of coal in such localities could be readily determined. The extensive interstream areas, however, are generally grassed over, affording but few scattered exposures, so that it is very difficult from a surface examination to determine the mineral value of the land.

Good topographic maps were available for all of the area examined and were used in the field as base maps on which to plat the coal outcrops and other geologic data. In the Indian reservation the topography for most of the townships was sketched at the same time that the Land Office surveys were made—an innovation for work of this class, affording plats on the scale of 2 inches to the mile, made directly in the field with special reference to the land subdivisions. The only exception to this procedure was in the northwestern part of the reservation, where the topography of the Browning and Chief Mountain quadrangles had already been sketched and was transferred to the township plats after the Land Office surveys were completed. The land corners are well marked and easily found in all parts of the region, especially on the Indian reservation, where iron pipes marking the allotments to the Indians have been placed on a large percentage of the corners. In the Valier coal field on Birch Creek the 6 miles of sinuous outcrop of the nearly horizontal coal bed was traversed with the stadia and plane table. But in the Blackfeet coal field, between Greasewood Creek and the Middle Fork of Milk River, the rocks dip steeply and the outcrop of the coal beds make nearly straight lines, all trending in the same direction. These were easily located at points where they cross the land lines, without recourse to the plane table.

The investigation was carried on by the writer, working alone, beginning in July, 1911, and continuing through a part of each of the field seasons of 1912 and 1913.

TOPOGRAPHY.

RELIEF.

The area described in this report lies on the west border of the Great Plains region, at the foot of the Rocky Mountains. (See Pl. XV.) The front range of the mountains rises with a wall-like abruptness from the plains without marked foothills. As seen from elevated points on the mountains, the plains appear to extend indefinitely eastward as a single surface with monotonous regularity. On closer examination, however, the part of the plains in the area here treated proves to have considerable relief, with low plateau-like areas in places, together with extensive dissected tracts along the principal streams. The total range of elevations on the general slope of the plains is about 2,500 feet. This lies between altitudes of about 6,000 feet on the plateau-like areas at the base of the mountains and 3,500 feet, the general elevation of the plains on the east edge of the area mapped. Along the valleys of the main streams in the south half of the area, such as Cut Bank and Two Medicine creeks, the relief between the valley floor and the general level of the adjacent plains ranges from 350 feet in the lower parts of the valleys through gradually increasing slopes to about 1,200 feet at their upper parts, near the front of the mountains. In the northern part of the region, however, in the valleys of the several forks of Milk River, which are much feebler streams than those above mentioned, the corresponding relief ranges only from 300 to 700 feet. In the extreme northeastern part of the area, the valley of St. Mary River, which not only carries a very vigorous stream but also has been heavily glaciated, has a relief of 1,000 to 1,600 feet.

The topographic types that give a distinctive character to the surface features in different parts of the region are (1) high-level sloping plains or plateau-like areas, (2) low-level plains, (3) escarpments, two of which are continuous across the entire area, (4) badlands, and (5) glacial moraines of considerable extent. The high-level plains are found in the western part of the region, adjacent to the mountains, in numerous isolated tracts from a fraction of a square mile to 40 square miles or more in extent and are doubtless remnants of an older, almost perfectly formed plain. They are covered with a veneer of gravel made up of rock types found in the adjacent mountains, and have remarkably smooth surfaces with a very regular slope to the northeast, away from the mountains. Milk River Ridge and St. Marys Ridge are typical of the larger of these areas. Below these higher plains are found lower plains that are much more extensive and merge eastward into the general level of the Great Plains region. Where best developed these plains also carry a veneer of gravel and have an even slope eastward away frcm the mountains. The best examples of the lower plains are Carlow Flat, an extensive and very evenly graded surface crossed by the Great Northern Railway west of Cut Bank, and the equally well-developed plain lying between Cut Bank Creek and Greasewood Creek a few miles northwest of Browning.

In the eastern part of the field, extending northward from Ethridge on the Great Northern Railway, there is a very striking sandstone escarpment, locally known as "the rim." This scarp is continuous for 35 miles, reaching almost to the Canadian line at Sweet Grass. It faces eastward and ranges from 350 to 600 feet in height. It is made up of the Virgelle sandstone, lying practically horizontal, whose massive upper member forms continuous cliffs of bare rock that are impassable in most places. About 30 miles to the west is a second escarpment that is a close counterpart of the first. It trends northward and is made up of the Horsethief sandstone. It is best developed in Rim Rock Butte and Horsethief Ridge, between Cut Bank Creek and Milk River, although there are extensions of it to the south, notably at Family, on Two Medicine Creek, and southward from Fourhorns Lake, in the southern part of the Indian reservation. Both of these escarpments are due to the greater resistance to erosion offered by the sandstone compared with that offered by a soft shale which lies beneath it. Near the mountains, in a belt about 15 miles wide extending northeastward entirely across the Indian reservation, where all the rocks are much disturbed, the same two escarpment-forming sandstones appear, where steeply tilted, as persistent hogback ridges as much as 3 miles in length.

The fact that several of the formations in this region are soft and easily eroded has led to the development of extensive badland areas in many places where the relief is abrupt. On Milk River near Landslide Butte, in the northern part of the field, is a worthless area of highly dissected topography that lies along the river valley for a distance of about 7 miles and extends back on each side as much as 2 miles. A similar but more extensive area cut in rocks of the same kind lies along Two Medicine Creek, where, from the mouth of Badger Creek downstream, typical badlands are developed in a belt about 12 miles long and 1½ miles wide. There are less extensive areas of similar topography in many other places, principally along the main streams.

The surface of the region has also been modified by glaciation during several distinct stages in Pleistocene time. Bowlder clay and other drift deposited at the time of the last advance of the glaciers which invaded the area, both from the high mountains on the west and from Canada on the northeast, cover large tracts and effectually conceal the underlying Tertiary (?) and Cretaceous bedrock formation. The drift is in some places as much as 250 feet thick. In the eastern half of the region there is a bowlder-strewn belt of the northeastern continental drift that has a rough kettle and moraine topography and is continuous from the valley of Milk River, on the north edge of the region, eastward and southward for over 40 miles. In the western half of the region the upper parts of the valleys of St. Mary River and Cut Bank Creek are thickly strewn with drift of mountain glaciers that came from the west. Farther south much more extensive glaciation centering along the valley of Two Medicine Creek extended 38 miles from the mountain front, leaving considerable areas of rough moraine. The largest of these areas extends from the region between Willow and Cut Bank creeks, near Browning, eastward to Carlow Flat and Two Medicine Creek.

DRAINAGE.

The streams on the plains of northern Teton County flow in a general northeastward direction, away from the mountains, and the principal valleys are parallel. Those that head in the mountains and therefore are clear and swift perennial streams are Birch, Badger, Two Medicine, and Cut Bank creeks and St. Mary River. Milk River and its several forks, on the other hand, do not head in the mountains, and are therefore relatively sluggish and muddy. St. Mary River is tributary to Hudson Bay, whereas the other streams form part of the Missouri River system. Except during the June rise all of the streams in the region can be forded at numerous wagon crossings. The mean annual rainfall in the eastern half of the country is somewhat under 20 inches, and that area is therefore poorly watered except by the streams coming from the west.

GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

The geologic formations in the region here described are all sedimentary in origin and range in age from Lower Cretaceous to probably basal Tertiary. All the rocks are apparently conformable, there being no recognizable break or disturbance between any of them or any evidence that points to the existence of an important erosion interval. The sequence of the formations in the Upper Cretaceous part of the section is different from that so far described for any other locality in Montana, owing to the fact that in this region the marine invasion represented by the Claggett shale did not extend so far west as the present position of the Rocky Mountain front between latitudes 48° and 49° N. An account of these interesting relations has already been published.[1]

Two of the formations, the Colorado and Bearpaw shales, are unquestionably of marine origin and were laid down during separate epochs in which a comparatively shallow sea covered the entire region. The remaining formations are mainly of continental origin—that is, they are irregularly bedded rocks that were for the most part rapidly deposited by stream and wind action over land areas that were only slightly above sea level and thus afforded the marshes and swamps necessary for the accumulation of the vegetable matter forming the coals now found in these beds.

The succession of formations, together with the principal features of the lithology, are outlined in the following table:

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[1] Stebinger, Eugene, The Montana group of northwestern Montana: U. S. Geol. Survey Prof. Paper 90, pp. 61-68, 1915.

Formations occurring in the plains portion of northern Teton County, Mont.

System.	Series.	Group and formation.		Thickness in feet.	Character of the rocks.
Quaternary.	Recent.	Alluvium.			Deposits of small extent found along flood plains of the larger streams.
	Pleistocene.	Glacial drift.			Bowlder clay, gravel, and lake silt and clay. Contains bowlders and cobbles of granite, gneiss, quartzite, etc., transported from other regions. Deposits are of several stages not distinguished in this report.
Tertiary (?).	Eocene (?).	Willow Creek formation.		720+	Variegated clay and soft sandstone, chiefly maroon to chocolate-brown, with subordinate gray, yellow, and greenish-gray beds. Fragments of fossil bones are common. Clay in many places contains thin lenticular beds of purplish-gray limestone. Forms a red soil over large areas. Top not seen.
		St. Mary River formation (coal bearing).		980	Alternating clay, clay shale, and soft sandstone, the sandstone is much cross-bedded and ripple-marked. Colors are gray to greenish gray, with a few red layers in the clay. Contains a few thin lenticular limestones, many fragments of dinosaur bones, and fossil shells.
Cretaceous.	Upper Cretaceous.	Montana group.	Horsethief sandstone.	225–375	Gray to greenish-gray sandstone, weathering buff. Thin bedded and somewhat shaly in lower half. In upper half generally massive and concretionary, weathering in castellated forms. In places near the top contains titaniferous magnetite. Has many shell beds, mainly of oysters.
			Bearpaw shale.	490	Dark-gray clay shale with a few limestone concretions. Contains abundant marine shells. Forms a subdued rounded topography.
			Two Medicine formation (coal bearing).	1950	Gray to greenish-gray clay and soft irregular sandstone, which is most abundant in the lower 250 feet. In places thin beds of red clay and nodular limestone. Contains an abundant reptilian fauna of Judith River types, besides leaves and shells. Contains coal beds near the base and at the top.
			Virgelle sandstone.	220	Gray to buff coarse-grained, much cross-bedded massive sandstone, with many ferruginous concretions in upper half. In lower half slabby gray sandstone, becoming shaly toward the base.
		Colorado shale.		1,500±	Bluish-gray shale with a few limestone concretions. Contains an abundance of marine shells. Forms a subdued and rounded topography. Complete undisturbed section not present.
	Lower Cretaceous.	Kootenai formation.		2,000±	Gray sandstone and shale, alternating with maroon clay shale and massive gray sandstone. Contains a conglomerate 6 to 50 feet thick near the center. Contains a few leaves and fresh-water shells. Complete undisturbed section not present.

NON COAL-BEARING FORMATIONS.

In addition to the glacial deposits and the two marine formations (the Colorado shale and Bearpaw shale), four of the formations, the Kootenai formation, the Horsethief and Virgelle sandstones, and the Willow Creek formation, consisting mainly of deposits of continental origin, are not coal-bearing in the region here described. All these formations may contain small fragments or pockets of coal, or even seams as much as several inches in thickness, but it is practically certain that they do not contain valuable coal beds. Fragments of coal a few inches in size are often found in exposures of glacial drift, especially in the eastern part of the area. These fragments were transported considerable distances and should not be assumed to indicate the existence of valuable beds of coal near at hand. Thin seams of coal in the Kootenai and Willow Creek formations and pockets of coal in the Virgelle and Horsethief sandstones are very unlikely to thicken with depth and do not justify extensive prospecting.

The Kootenai formation is the oldest formation in the plains portion of northern Teton County. It is exposed only in the belt of disturbed rocks lying adjacent to the mountains. In this disturbed belt folding and especially thrust faulting have so deformed the rocks that their exact sequence and thickness can not be determined, but the exposures are good and the noncoal-bearing character of the formation is fairly certain. A few miles beyond the west border of the area the Kootenai overlies a black marine shale carrying Jurassic fossils. This, together with the fact that it immediately underlies the Colorado shale, gives the formation the approximate stratigraphic position of the Kootenai of the Great Falls region, 150 miles to the southeast, which has in turn been correlated with the Kootenai formation of British Columbia and Alberta by means of the characteristic fossil plant remains, mainly leaves, found at both localities. Black carbonaceous shale, with coal beds 6 or 8 inches in thickness, is the only coaly matter present in the formation in the area here discussed. The absence of greater amounts of coal is rather surprising, in view of its extensive occurrence in the typical area to the north and also in the Great Falls region. In the fields in the vicinity of Crows Nest Pass, Alberta and British Columbia, the Kootenai contains as much as 215 feet of coal in less than 2,000 feet of strata, and in the Great Falls region the coal bed near the base of the formation is in places 14 feet thick.

The Virgelle sandstone and Horsethief sandstone contain no coal, but are of considerable importance as key rocks marking the position of valuable coal beds that lie immediately above them. In each of the three districts in the region containing valuable coals the beds lie within 10 or 15 feet of the top of one or the other of these two sandstones, which stand out as ridges or escarpments, thus serving admirably as markers. This feature is accentuated by the fact that the upper part of each of the formations is a massive cliff-making sandstone. In the Blackfeet field prospectors should depend on following the ridges or "reefs" of the Horsethief sandstone and digging for the coal bed that lies just above it. In the Valier field and in the district on Milk River cliffs of the sandstone lying nearly horizontal are reliable markers of coal above them.

The Willow Creek formation, composed of clay shale and soft sandstone, is lithologically identical with the coal-bearing St. Mary River formation lying just below it, except that the Willow Creek rocks are characterized by a dominantly red color instead of the light-grayish tints of the St. Mary River formation. It is not coal bearing in the area described and is easily traced by means of the red soil associated with it. To the north, in central Alberta, the red color of these rocks disappears and the strata at the same position are coal bearing.

COAL-BEARING FORMATIONS.

TWO MEDICINE FORMATION.

The rocks here designated Two Medicine formation, about 2,000 feet thick, comprise a great mass of rudely bedded whitish to gray clay and sandy strata. The irregular bedding of these rocks suggests a hasty and unstable sedimentation, which was largely of stream character. This formation, together with the underlying Virgelle sandstone, when traced northward proves to be identical with the rocks designated Belly River series by the Canadian geologists. In western Montana, however, the Virgelle sandstone has been mapped over considerable areas as a distinct unit easily separable from the overlying softer rocks, so that the term Belly River could not be consistently used in the area here described.

The Two Medicine formation is coal bearing at three horizons—at the base of the formation, 250 feet higher, and at the top. Coaly matter is also present at many other positions in the formation in the form of beds of black carbonaceous shale 2 to 5 feet thick. The lower 200 feet of the formation is more sandy than the remainder, probably half of this part consisting of massive sandstone in irregular beds as much as 50 feet in thickness. Several of the more persistent of these sandstones can be traced for a mile or two, but in general the strata throughout the formation appear and disappear within a few hundred feet. Above the basal sandy portion the formation is made up predominantly of clay and clayey shale of whitish to greenish-gray tints interbedded with a small amount of soft gray sandstone. Beds of red clay 1 to 2 feet thick are sparingly distributed throughout these rocks and in places produce a delicate red line in the badland exposures so characteristic of the formation.

Fossils are abundant in the Two Medicine formation and include vertebrate, plant, and mollusk remains of many species. Bone fragments of dinosaurs of Judith River types, both herbivorous and carniverous, and also of turtles can be found in almost any extensive exposure. Entire limb bones 4 to 5 feet in length belonging to the larger dinosaurs were found at several localities. The mollusks are represented mostly by brackish and fresh water forms, especially the latter. Beds made up almost exclusively of unios are present at many horizons, in some places closely associated with the dinosaur bones. A single marine invasion of brief duration while this formation was being deposited is represented by shells of the Claggett to Fox Hills near-shore fauna[1] found in sandstone about 200 feet above the base of the formation. The plant remains are mainly leaf impressions and silicified wood. The leaves are all of modern-appearing conifer and broad-leaved types. The fossil wood is distributed throughout the formation, knots and entire sections of compressed tree trunks being common.

In the eastern half of the area mapped the Two Medicine formation, lying nearly horizontal, crops out in a broad belt from 20 to 30 miles wide, making up the largest areal geologic unit in this region. In this belt of rocks the formation is well exposed in all the larger stream valleys from Birch Creek to Milk River. The lower half of the formation is exposed along 12 miles of the lower part of Birch Creek valley west of Valier. On Two Medicine Creek the entire formation can be minutely studied in practically continuous exposures that extend for over 20 miles westward from the mouth of the stream. In the vicinity of Cut Bank the lower sandy portion of the formation is completely exposed along 10 miles of the sharply trenched valley of Cut Bank Creek, and on Milk River, north of Landslide Butte, the upper 800 feet of the formation is laid bare in extensive badlands. In the belt of disturbed rocks adjacent to the mountain front many tilted sections of the formation are exposed, but the strata can not be studied advantageously because as a rule their true sequence can not be definitely ascertained.

ST. MARY RIVER FORMATION.

The rocks included in the St. Mary River formation were first studied and described by geologists of the Canadian Survey along St. Mary River in Alberta, where they crop out for about 20 miles in the vicinity of the town of Spring Coulee. From this locality the formation is continuous southward across the international boundary into the area here described. It is composed mainly of clay and clay shale and partly consolidated sand of gray to greenish-gray color. A few buff-weathering sandstones which are not persistent are present in places. Red clay in beds a few feet thick is intercalated throughout the formation, and some lenticular beds of limestone of various tints are also present. Bone fragments of undetermined dinosaurs, usually associated with shell beds of unios, are abundant in these rocks. Coal occurs at the bottom of the formation and also at the top. On the whole the similarity to the underlying Two Medicine formation is very striking, and the two formations were doubtless laid down under similar stream conditions.

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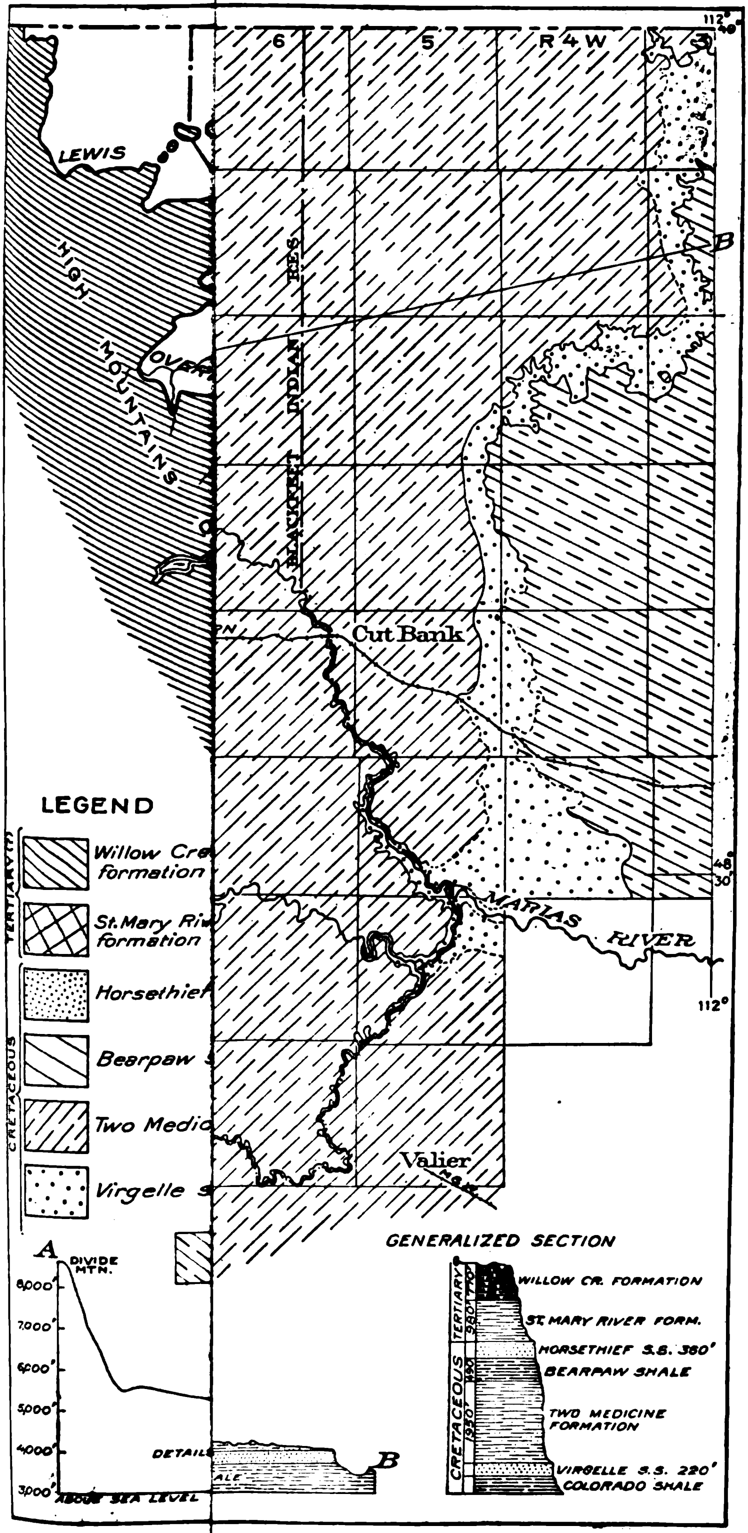
[1] Stanton, T. W., Some variations in Upper Cretaceous stratigraphy: Washington Acad. Sci. Jour., vol. 3, p. 66, 1913.

Although the St. Mary River formation is exposed at many localities in the area here described, there is no place where the complete sequence of the formation can be studied in detail. The best exposures are on the upper 7 miles of Little Rocky Coulee, where all but the lower third of the formation is laid bare in a small badland area. The base of the overlying Willow Creek formation is determinable solely by a change in color from grayish rocks to those that are dominantly red. This takes place in a 50-foot transition zone, in which red beds alternate with white to gray beds. In the disturbed belt of rocks adjacent to the mountains it is very difficult to distinguish the St. Mary River and Two Medicine formations, because their composition and fossils are closely alike. If the underlying or overlying formations associated with each are present in normal contacts, the identity of the rocks can usually be determined. Contrasted with the Two Medicine formation the St. Mary River formation is thinner and contains much less fossil wood and fewer leaves and shells.

STRUCTURE.

Structurally the area described in this paper can be divided into two large units, differing greatly in the amount of deformation to which the rocks have been subjected. A slightly curving line shown on the geologic map (Pl. XV), extending northward from a point on Birch Creek in R. 9 W. to a point on the Canadian boundary in T. 37 N., R. 12 W., marks a sharp transition between an area on the east, in which the beds are nearly horizontal and undisturbed, and an area on the west, adjacent to the mountain front, in which the rocks have been folded and faulted to an unusual degree. The eastern area on the map is characterized by a simple arrangement of broad belts of outcrop with regular north-south trend, and the western area by a relatively complex arrangement of formation patterns.

In the horizontal rocks there is a slight, generally westward dip, varying from near zero to 5° in gentle undulating flexures with an


112°
40'
6
5
R 4 W
3
LEWIS
HIGH
MOUNTAINS
OVER
BLACKFEET INDIAN RES
B
Cut Bank
MARIAS RIVER
48°
30'
112°
Valier
LEGEND
TERTIARY(?)
Willow Cre
formation
St. Mary Ri
formation
Horsethief
Bearpaw
Two Medic
Virgelle
CRETACEOUS
A
DIVIDE MTN.
8,000'
7,000'
6,000'
5,000'
4,000'
3,000'
ABOVE SEA LEVEL
DETAIL
ALE
B
GENERALIZED SECTION
TERTIARY
170'
980'
CRETACEOUS
1190'
1930'
WILLOW CR. FORMATION
ST. MARY RIVER FORM.
HORSETHIEF S.S. 350'
BEARPAW SHALE
TWO MEDICINE FORMATION
VIRGELLE S.S. 220'
COLORADO SHALE

average dip of not over 2°. As a result of this average westward dip of the bedrock formations, the youngest, or, in other words, the highest stratigraphically, the Willow Creek formation, lies farthest west in these nearly horizontal rocks, whereas the oldest, the Colorado shale, lies farthest east, on the east edge of the tract. Thus, one traveling westward up any of the principal stream valleys, as, for instance, from Marias River, up Cut Bank Creek, Two Medicine Creek, or Birch Creek, would cross all the formations present, in sequence from older to younger, in a distance of 35 to 50 miles. Between the southern slopes of Milk River Ridge and the international boundary a broad, open syncline whose steeper limb is on the west, lies on the west border of the area of horizontal rocks. Its axis is between 1 and 2 miles east of the line marking the transition to the disturbed belt of rocks and closely parallels that line. Farther north in Alberta this syncline broadens into a much more extensive feature, which continues to Calgary and beyond. On the south it is practically coextensive with the Willow Creek formation and does not reach beyond Cut Bank Creek.

Minor undulations of the strata in the area of nearly horizontal rocks can be seen in detail only along the principal stream valleys. They are gentle monoclinal flexures in which the inclined beds are on the west, although in a few places reverse dips produce slight anticlinal folds in the generally westward-dipping rocks. The change in structure from the nearly horizontal rocks in the eastern half of the reservation to the steeply dipping disturbed rocks in the western half is very abrupt. Where exposures are good, especially along the major stream valleys, this change can be seen to occur within a few feet, there being no intermediate zone of gentle folding.

The disturbed belt of rocks adjacent to the mountains occupying the western third of the region here described is a small part of a structural area from 15 to 20 miles wide, lying at the base of the Rocky Mountains, which extends at least 80 miles southeastward to and beyond Sun River and a much greater distance northwestward across Alberta. Throughout this area the rocks have been intensely folded and faulted by thrust stresses that acted from the southwest. In many places the individual formations are so much crushed and broken that it is impossible to identify them with certainty. The one constant feature in this whole disturbed area is the uniform northwesterly strike of the rocks. Because of this parallelism of strike the more resistant sandstones of the several formations appear as numerous parallel strike ridges, the same formation being repeated within short distances.

THE COAL.

GENERAL FEATURES OF OCCURRENCE.

All the coal found in northern Teton County is of medium bituminous grade. It occurs in the Two Medicine formation and the St. Mary River formation, which have already been described. The valuable coal beds occur at five horizons in these formations, three in the Two Medicine and two in the St. Mary River.

The map and sections on Plate XVI present graphically the important coal data for the area. All the valuable occurrences of coal are shown, the outcrops of beds that could be traced being indicated by black lines. Sections of the coal at many points on these outcrops are given, besides those of numerous scattered outcrops from beds that were either too thin or too much covered to warrant mapping. The scale of the map is too small to differentiate those parts of the outcrops where coal is actually exposed from the stretches that are grassed over or otherwise covered, but in the descriptions that follow, details of the actual outcrops upon which the tracing of individual beds depends are given.

For convenience in presenting the detailed accounts of the coal the area here described is divided into several units. The subdivision is more or less arbitrary, because the small amount of mining in progress does not afford a number of districts which are separate centers of development. The coals in the area of nearly horizontal rocks in the eastern two-thirds of the area are first described, taking in turn first the Valier field, then minor coals from the Two Medicine formation, and finally the coals from the St. Mary River formation. The coals in the disturbed belt of rocks occupying the western third of the area are described separately from those in the area of nearly horizontal rocks, because the great difference in structure in the two tracts will demand very different types of mining in each. The description of the Blackfeet field, the one important area in the belt of disturbed rocks, is first presented. Then an account is given of the minor coals occurring in the disturbed belt in the Two Medicine and St. Mary River formations.

COAL IN THE AREA OF NEARLY HORIZONTAL ROCKS.

VALIER FIELD.

The Valier field is about 7 miles northwest of Valier on Birch Creek. It contains at least 5 square miles of coal land, nearly all of which lies in secs. 28 to 33, T. 31 N., R. 5 W. The coal crops out along the creek in a sharply cut trenchlike valley about 200 feet deep and can be studied in detail for 2½ miles along the course of the stream. Because of the excellent exposures of the beds present, the coal was probably known to the pioneer cattle men in this region, and it has been actively mined for at least 15 years.

The coal occurs in two beds at the base of the Two Medicine formation. The lower of these beds rests directly on the light-gray cliff-making member of the Virgelle sandstone, which is continuously exposed for many miles down Birch and Two Medicine creeks in a steep-walled box canyon that extends to Marias River. A section of the coal-bearing strata measured at locality 6,[1] a short distance southwest of the west quarter corner of sec. 28, T. 31 N., R. 5 W., is as follows:

Section of coal-bearing rocks on Birch Creek, at locality 6 in sec. 29, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, soft gray, weathers to a buff tint.		
Upper coal bed:		
Coal		2
Shale, fissile, carbonaceous		8
Coal, clean and hard		4
Clay, gray and compact		2
Coal of good grade	1	6
Clay, gray	10	0
Sandstone, massive, white to gray	12	0
Clay, dark gray	4	0
Lower coal bed:		
Coal, very dirty, with a few clean streaks	1	4
Shale, fissile and carbonaceous	1	8
Coal, very dirty, with a few clean fragments	1	2
Clay, dark gray		10
Coal, clean and hard		8
Shale, carbonaceous and fissile	2	0
Sandstone, gray and massive, main member of Virgelle sandstone	50+	

The upper coal bed at this point is 2 feet 10 inches thick. The compact gray clay 2 inches thick in this bed, locally known as "bone," is a persistent parting that appears in all the exposures throughout the field. It is very regular both in thickness and appearance. The 12 feet of white to gray sandstone lying between the upper and lower coal beds is well exposed along the creek and is present as far as the coals persist. The lower bed, although it is over 7 feet thick, is everywhere too dirty to be worked, 8 inches being the greatest thickness of clean coal present.

The coal-bearing strata in this field lie nearly horizontal. In general they have a slight inclination, not exceeding 45 feet to the mile, in a direction about S. 75° W., which roughly parallels the upstream direction of Birch Creek. This dip, together with the uphill gradient of the creek, gradually carries the coal beds toward the water level of the stream, and the upper bed passes beneath the creek in secs. 31 and 32. Thus much of the coal in secs. 30, 31, and 32 lies beneath the level of Birch Creek.

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[1] Locality numbers refer to corresponding numbers on Plate XVI.

The farthest upstream exposure on Birch Creek of the upper bed is at locality 1, in the SE. ¼ sec. 31. Here the bed crops out for several hundred feet along the left bank of the creek, very close to water level. A section at this point is as follows:

Section of coal bed at locality 1, in the SE. ¼ sec. 31, T. 31 N., R. 5 W.

	Ft.	in.
Clay, gray.		
Shale, carbonaceous and fissile, with thin layers of coal		10
Coal, clean and hard		6
Clay parting		3
Coal, clean and hard	1	6
Clay, gray.		
Thickness of bed	3	1
Thickness of coal	2	0

The coal in both benches at this point seems to be of excellent quality. Even on a weathered outcrop it is hard, has a black shiny luster, and breaks out in cubic masses as much as 6 inches in size. The coal is prominently jointed in directions at right angles to each other. About 300 feet upstream this coal bed passes beneath the bed of the creek. At this point on the south side of the creek there is an excellent exposure of the rocks associated with the coal at the base of the Two Medicine formation, as follows:

Section of coal-bearing rocks exposed on Birch Creek in the SE. ¼ sec. 31, T. 31 N., R. 5 W.

	Ft.	in.
Top of bluff.		
Interval, partly covered, but presumably of clay and shale	30	0
Sandstone, coarse, gray to buff, making a ledge on the slope	25	0
Clay, white to gray	35	0
Sandstone, massive, most prominent stratum on the slope, cross-bedded, gray to white	30	0
Clay, gray	6	0
Coaly shale, fissile	3	0
Clay, white to dark gray	21	0
Clay and sandy clay, grading into sandstone	20	0
Coaly shale, black, fissile	3	0
Clay, dark gray, grading into sandstone	12	0
Coal, upper bed	2	3
Water level of creek.		

The next exposure of the upper coal bed on Birch Creek is a little over a quarter of a mile downstream, in the NW. ¼ sec. 32, on the east side of the creek, where the bed has been mined for a number of years by A. G. Blair. The coal crops out in the steep bluffs slightly above the high-water line along the creek and has been worked in several short entries. A section of the bed at this point is as follows:

Section of coal bed at Blair mine, in the NW. ¼ sec. 32, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, massive, gray and irregular.		
Clay shale, gray	5	0
Coaly shale, black and fissile	1	0
Coal, clean and hard		5
Clay parting, somewhat sandy		2
Coal, with a little sandy dirt [1]	1	7
Clay, gray.		
Thickness of bed	3	2
Thickness of coal	2	0

The upper bench is in some places not more than 4 inches thick and in others as much as 12 inches. It is a shiny, black, fairly hard coal, and locally shows some whitish dirt. The lower bench, in places, is as much as 1 foot 10 inches thick, thus giving a maximum thickness of 2 feet 10 inches for this bed. The lower bench is prominently jointed and often breaks out in large blocky masses as much as 2 feet square. Immediately north of locality 2, on the opposite side of the creek, the same bed crops out for 400 to 500 feet, a short distance above water level, and at one time was mined at this point to supply coal to the Indian school at the Holy Family Mission, on the Blackfeet reservation.

About a quarter of a mile northeast of the Blair mine the creek is cutting vigorously against its right bank, making a steep cut-bank face, which again exposes the coal bed. The croppings are continuous for nearly 1,000 feet at this locality. A section of the bed near the center of this exposure gave the following:

Section of upper coal bed at Slazak mine, in the NW. ¼ sec. 32, T. 31 N., R. 5 W.

	Ft.	in.
Clay, dark gray, grading upward into gray sandstone.		
Shale, carbonaceous, with streaks of good coal		10
Coal, clean and hard		6
Clay, compact, and gray bone		2
Coal, clean and well jointed	1	8
Clay, dark gray.		
Thickness of bed	3	2
Thickness of coal	2	2

There are three short entries on the bed at this exposure where mining has been carried on by Paul Slazak for a number of years. The roof of the coal is generally a dark-gray clay, which grades upward into a soft gray sandstone. It caves badly and is irregular, being replaced at many points by sandstone, although the thickness and character of the coal itself, with the 2-inch parting near the top, remain fairly constant.

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[1] Analysis 12427 on p. 138.

Near the south line of sec. 29, on the bend of the creek below the Slazak mine, the lower coal bed, here practically at water level, is seen for the first time by one traveling down the creek. It is very dirty, containing only a few streaks of clean coal, and on the whole is worthless as a fuel. Immediately below it can be seen the light-gray Virgelle sandstone, rising gradually above water level as it is followed by the eye downstream until it stands as a white cliff more than 50 feet in height at the farthest visible bend of the creek.

At locality 4, on the north side of the creek in the SW. ¼ sec. 29, the upper coal bed has been mined in a strip pit paralleling the outcrop for some distance. The section at this point is as follows:

Section of upper bed at locality 4, on Birch Creek, in the SW. ¼ sec. 29, T. 31 N., R. 5 W.

	Ft.	in.
Clay, soft, gray.		
Coal, dirty		4
Shale, carbonaceous and fissile		6
Coal, of good grade		6
Clay, compact gray bone		2
Coal, clean and hard, with rectangular jointing	1	9
Thickness of bed	3	3
Thickness of coal	2	7

Directly across the creek from the locality noted above there are two sharply cut coulees joining the creek at right angles from the southeast. The outcrop of the upper coal bed extends about 1,000 feet up each of these coulees in almost continuous exposure. In the western coulee there are two entries on the bed. The section of the coal is almost identical with that at locality 4.

A quarter of a mile east of locality 4, on the south side of the creek, there is a group of at least four entries extending along about 1,000 feet of outcrop of the upper bed. These entries are badly caved and have been abandoned. They were probably made during the first mining in this field. Henry Weimers was actively working one of these openings as early as 1901.

At locality 5, in the SE. ¼ sec. 29, both the upper and lower beds are exposed above the cliffs of massive Virgelle sandstone about 50 feet above creek level. The lower bed consists of 5 feet of black carbonaceous shale that weathers out in fissile papery layers. Interspersed through it are irregular streaks of clean coal as much as 4 or 5 inches thick. The section of the upper bed at this point is as follows:

Section of upper coal bed at locality 5, in the SE. ¼ sec. 29, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, gray, platy.		
Shale, coaly, with fragments of clean coal		11
Coal, clean and hard		4
Clay, of compact gray bone		2
Coal, clean and prominently jointed	1	11
Thickness of bed	3	4
Thickness of coal	2	3

The section of the coal zone on the opposite side of the creek, at locality 6, where both beds are also exposed, has already been given.

At locality 7, in the NW. ¼ sec. 28, on the east side of the creek, there is a small entry on the upper bed that was badly caved at the time it was examined. An exposure of the bed in a cut at the mouth of this entry measures as follows:

Section of coal bed at locality 7, in the NW. ¼ sec. 28, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, coarse, gray, grading upward into yellow clay	8	0
Shale, carbonaceous, with coaly layers		6
Coal, hard and shiny black		2
Clay, compact gray bone		2
Coal, of good grade and well jointed	1	7
Sand, gray.		
Thickness of bed	1	11
Thickness of coal	1	9

About 1,000 feet south of locality 7, on the same side of the creek and near the mouth of a small coulee entering the creek from the southeast, there is an entry about 100 feet long on the lower coal bed, which is the only entry driven on the lower coal in this field. The bed is well exposed as a thick black layer along the side of the coulee and on cursory examination might be mistaken for valuable coal. A section at the mouth of this entry is as follows:

Section of lower coal bed at entry 1,000 feet south of locality 7, in the SW. ¼ NW. ¼ sec. 28, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, firm, gray.		
Clay, gray, irregular		5
Coal		3
Clay, bluish gray		3
Coal, largest bench in bed		8
Shale, fissile, ash gray		6
Coal		3
Shale, fissile and coaly	2	1
Clay, gray	3	0
Sandstone, massive, gray, Virgelle sandstone	60+	
Thickness of bed	4	0
Thickness of coal	1	2

In the NW. ¼ sec. 29 is a large coulee which enters Birch Creek from the west and the lower part of which consists of a narrow rock gorge in Virgelle sandstone. There are several croppings of the upper coal bed in the lower three-fourths of a mile of this coulee. At locality 8, in the SE. ¼ sec. 20, the bed measures as follows:

Section of coal bed at locality 8, in the SE. ¼ sec. 20, T. 31 N., R. 5 W.

	Ft.	in.
Sandstone, yellowish gray, soft.		
Shale, carbonaceous and fissile		6
Coal		4
Clay, compact gray bone		2
Coal, clean and prominently jointed	1	4
Thickness of bed	2	4
Thickness of coal	1	8

This is the northernmost exposure of the bed in this field. It is almost identical with the exposures all along the creek to the opposite end of the field, the thin parting with a thick bench of coal below it and a thin one above being present at every point examined. A quarter of a mile south of locality 8, on the south bank of the coulee, the sandstone forming the roof of the upper bed along the coulee has been baked throughout its lower 4 feet to a brick-red tint, the color being deepest toward the base of the sandstone. This red color was doubtless caused by the burning of the coal at this point and is noteworthy as the only evidence seen in this region of the burning of coal along the outcrop, a feature which is so common in the coal and lignite areas of eastern Montana.

Toward the north both the coal beds in the Valier field thin out and lose their identity near the south line of sec. 21. On the east side of the creek there is no trace of the upper bed with its characteristic clay parting north of the small entry at locality 7, except a small bloom in the first coulee to the northeast. Beyond this point the rocks at the horizon of the bed are concealed for about half a mile on gentle slopes on both sides of the creek by the slumping of the gravel and till of the overlying glacial drift. The beds at the coal horizon can be seen next on both sides of Birch Creek near the center of sec. 21 at the top of the box canyon cut in the Virgelle sandstone. Here they consist of 15 feet of yellow iron-stained sand, much cross-bedded, which contains lenses and thin irregular streaks of coal in great abundance. The largest of these lenticular masses seen measured 2½ feet thick by 8 feet in greatest dimension and was sharply outlined in the surrounding sand. Half a mile farther north, on the north line of sec. 21, the coaly matter in this sand is represented by a bed 2½ feet thick, of fissile carbonaceous shale with streaks of clean coal, which can be followed for about half a mile and then disappears.

At the time of the examination of the Valier field there were no data available from well borings deep enough to have reached the coal horizon in the areas on either side of Birch Creek back of the outcrop of the one workable coal bed present. Inference as to the area underlain by this coal bed must therefore be based on the extent and continuity of its outcrop. The northeastward limits of the coal area can be determined with a fair degree of accuracy where the bed thins out in that direction, but southwestward the coal is last seen passing beneath the bed of the creek in sec. 31, T. 31 N., R. 5 W., and the distance to which it extends underground in that direction is very uncertain. The bed, though thin, is very regular and persistent from the northeast extremity of its outcrop to the point where it passes beneath the creek, and it may underlie a large area to the southwest.

The coal in the one workable bed on Birch Creek seems to be very uniform in character throughout its extent. The fresh coal at a working face has a bright luster and is fairly hard. In places it shows fine streaks of whitish dirt. It is everywhere prominently jointed in two directions at right angles to each other, spaced at irregular distances of 2 feet or less. This makes the coal break out in large blocks, many of which are as much as 2 feet square and as thick as the entire lower bench of the coal bed at the point being worked. The coal withstands weathering very well and does not slack on exposure. A 20-inch cube of it which had been kept for display, was examined and found to be firm and intact after over a year's exposure to the weather. Even the weathered face of the coal on natural exposures is hard, and the coal breaks out in cubic fragments of all sizes up to 6 inches across. The coal appears to be of about the same quality in all parts of the field. Its chemical composition is shown by analysis 12427 in the following table:

Analyses of coal samples from northern Teton County, Mont., and adjacent regions.

[Made at the laboratory of the Bureau of Mines; A. C. Fieldner, chemist in charge.]

	Location.				Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
	Quarter.	Sec.	T.N.	R.W.				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Blair mine, Valier field..	NW.	32	31	5	12427	1.3	A.	6.6	40.3	39.2	13.89	3.08	5.16	60.71	1.13	16.03	6,070	10,930
							B.	5.3	40.9	39.7	14.07	3.12	5.09	61.51	1.14	15.07	6,150	11,070
							C.	....	43.2	41.9	14.87	3.30	4.74	64.97	1.21	10.91	6,495	11,690
							D.	....	50.7	49.3	....	3.88	5.57	76.32	1.42	12.81	7,630	13,740
Allison mine, Cut Bank Creek.	NE.	29	34	6	12494	2.9	A.	7.8	30.2	34.3	27.7	1.78	....	....	....	....	4,835	8,710
							B.	5.1	31.1	35.2	28.6	1.83	....	....	....	....	4,980	8,970
							C.	....	32.8	37.1	30.1	1.93	....	....	....	....	5,245	9,450
							D.	....	46.9	53.1	....	2.76	....	....	....	....	7,505	13,510
Stone prospect, Blackfeet field.	SE..	35	36	12	12602	2.3	A.	8.0	35.4	44.2	12.45	1.00	5.17	62.92	1.46	17.00	6,135	11,050
							B.	5.8	36.2	45.3	12.74	1.02	5.03	64.40	1.49	15.32	6,280	11,310
							C.	....	38.5	48.0	13.53	1.09	4.65	68.39	1.59	10.75	6,670	12,010
							D.	....	44.5	55.5	....	1.26	5.38	79.00	1.84	12.43	7,715	13,890
Paisley prospect, St. Mary River.	......	8	37	13	3934	1.8	A.	7.0	32.0	47.4	13.6	.86	....	....	....	....	6,040	10,870
							B.	5.2	32.6	48.3	13.9	.88	....	....	....	....	6,150	11,070
							C.	....	34.4	51.0	14.6	.93	....	....	....	....	6,495	11,690
							D.	....	40.3	59.7	....	1.09	....	....	....	....	7,605	13,690
Mine of Cottonwood Coal Co., Sand Coulee, Cascade County.	NW.	36	19	4 E.	4115	2.4	A.	6.0	28.5	51.4	14.14	2.38	4.46	63.61	.91	14.50	6,195	11,150
							B.	3.7	29.1	52.7	14.49	2.44	4.28	65.18	.93	12.68	6,350	11,430
							C.	....	30.3	54.7	15.04	2.53	4.03	67.67	.97	9.76	6,590	11,870
							D.	....	35.6	64.4	....	2.98	4.75	79.66	1.14	11.47	7,760	13,970
Galt mine, Lethbridge, Alberta, Canada.	......	......	......	......	14882	2.0	A.	9.8	40.1	43.3	6.77	.71	5.60	64.99	1.73	20.20	6,340	11,410
							B.	7.9	41.0	44.2	6.91	.72	5.49	66.32	1.77	18.79	6,470	11,640
							C.	....	44.5	48.0	7.50	.79	5.00	72.04	1.92	12.75	7,030	11,650
							D.	....	48.1	51.9	....	.85	5.41	77.88	2.08	13.78	7,600	13,680
City of Lethbridge mine, Lethbridge, Alberta, Canada.	......	......	......	......	14883	2.8	A.	10.6	36.4	36.3	16.73	.89	5.15	55.94	1.44	19.85	5,455	9,820
							B.	8.0	37.5	37.3	17.21	.92	4.98	57.55	1.48	17.86	5,610	10,100
							C.	....	40.8	40.5	18.71	1.00	4.45	62.55	1.61	11.68	6,100	10,980
							D.	....	50.1	49.9	....	1.23	5.47	76.95	1.98	14.37	7,505	13,710

In the table the analyses are given in four forms, marked A, B, C, and D. Analysis A represents the composition of the sample as it comes from the mine. This form is not well suited for comparison, because the amount of moisture in the sample as it comes from the mine is largely a matter of variable local conditions, and consequently analyses of the same coal expressed in this form may vary widely. Analysis B represents the sample after it has been dried at a temperature a little above the normal until its weight becomes constant. This form of analysis is best adapted for general comparison. Analysis C represents the theoretical condition of the coal after all the moisture has been eliminated. Analysis D represents the coal after all the moisture and ash have been theoretically removed. This is supposed to represent the true coal substance, free from the most abundant impurities. Forms C and D, which are obtained from the others by recalculation, represent theoretical conditions that do not exist.

In the analytical work it is not possible to determine the proximate constituents of coal or lignite with the same degree of accuracy as the ultimate constituents. Therefore the air-drying loss, moisture, volatile matter, fixed carbon, and ash are given to one decimal place only, whereas the ash (in the ultimate analysis), sulphur, hydrogen, carbon, nitrogen, and oxygen are given to two decimal places. The determination of the calorific value to individual units is not reliable, hence in the column headed "Calories" the heat values are given to the nearest five units, and in the column headed "British thermal units" they are given to the nearest tens, as the value of a British thermal unit is about one-half that of a calorie.

It is evident from the table that coal from the Valier field compares very favorably with either of the two coals which compete with this coal in its home market, namely, that from the Great Falls field, Montana, and that from the Belly River field (Lethbridge), Alberta. The average heating value of two samples of Lethbridge coal collected by the writer and determined by the Bureau of Mines was, on the basis of air-dried coal, 10,800 British thermal units. (See analyses 14882 and 14883.) For the Great Falls coal (see analysis 4115) this value is 11,400 British thermal units, and for the Valier coal (see analysis 12427) it is 11,070 British thermal units. The ash content on the air-dried basis, is 10.3 for Lethbridge coal, 18.4 for unwashed run-of-mine coal from Great Falls, and 14.1 for Valier coal. The excess of ash in the Valier coal over that in the coal from Lethbridge is considerable, but not as great as a casual inspection of the fuel leads one to expect. This is due to the fact that the impurities in the Valier coal are whiter than those in the coal from Lethbridge, so that the Valier coal gives the impression of being a much dirtier fuel. On the whole it seems clear that coal from the Valier field belongs to the bituminous class and compares favorably with the other bituminous coals of the same region.

SMALL COAL BEDS IN TWO MEDICINE FORMATION.

COAL ON TWO MEDICINE CREEK.

There are a number of exposures of either thin or very dirty coals in the badlands along the lower 10 miles of Two Medicine Creek. In going up the creek from its mouth the first of these exposures is found at locality 9, in the NE. ¼ sec. 18, T. 31 N., R. 5 W. Here 60 feet above water level of the creek, immediately above massive cliffs of Virgelle sandstone and therefore at the same horizon as the coal of the Valier field on Birch Creek, there is 1 foot 5 inches of coal. The upper 8 inches of this bed is very dirty, but the remainder seems to be fairly clean bituminous coal. The westward dip of the strata carries this bed down to creek level three-fourths of a mile upstream, in the NW. ¼ sec. 18.

Six miles farther up the creek there is a persistent bed of coal and coaly shale that can be followed for nearly 3 miles. This bed lies about 250 feet above the base of the Two Medicine formation and is approximately at the same stratigraphic position as that of more extensive outcrops of coal farther north on Cut Bank Creek. At locality 10, in the NW. ¼ sec. 3, T. 31 N., R. 6 W., the bed lies just below a 15-foot massive gray sandstone and includes 4 feet of dirty coal, which might better be described as fissile carbonaceous shale containing fragments of pure coal. A quarter of a mile west of locality 10 the bed can be seen at the level of the creek. Farther downstream, on the south side of the creek, it can be traced along several miles of outcrop but does not contain clean coal at any point.

Above locality 10 the badlands in the next 3 miles along Two Medicine Creek show many outcrops of black carbonaceous shale beds, none of which contains more than a few small lenses of coal. The largest of these beds is exposed as a prominent black outcrop that can be followed for over half a mile along the sides of the principal coulee in sec. 36, T. 32 N., R. 7 W.

COAL ON LOWER PART OF CUT BANK CREEK.

The beds at the base of the Two Medicine formation which carry the coal in the Valier field are exposed above the bold cliffs of Virgelle sandstone along the lower 10 miles of Cut Bank Creek. A careful search was made in the clay and sandstone, but no coal was found. On the west side of the creek in sec. 5, T. 32 N., R. 5 W., the beds of this horizon contain several feet of black carbonaceous shale, which crops out at intervals across sec. 5. A mile farther downstream this carbonaceous shale is replaced by yellowish ferruginous sand and sandy clay, similar to that found at the same stratigraphic position on the north edge of the Valier field.

About 250 feet above the base of the Two Medicine formation there is a bed of coal and coaly shale that can be traced continuously for 10 miles along the valley of Cut Bank Creek from a point near the mouth of Spring Creek, 4 miles south of the town of Cut Bank, to a point 3 miles above the mouth of Big Rocky Coulee. The bed is approximately the same as the coal of locality 10, on Two Medicine Creek. It is thus evident that coal-forming conditions in this vicinity at this stage were fairly widespread for the distance between the northernmost exposure on Big Rocky Coulee and those farther south is over 20 miles.

To the north, up the valley of Cut Bank Creek, the first outcrop noted that should probably be referred to this bed is in the NE. ¼ sec. 17, T. 32 N., R. 5 W. Here, at an altitude of 3,695 feet, in the bottom of the coulee crossing this quarter section, there are prominent croppings of black coaly shale with many small lenses of clean coal. About 1½ miles above the mouth of Spring Creek, in the S. ½ sec. 26, this coal bed is exposed for about 1,000 feet along both sides of the creek. A section of the rocks at this point is as follows:

Section of coal-bearing rocks at locality 11, on Spring Creek, in the S. ½ sec. 26, T. 33 N., R. 6 W.

	Ft.	in.
Shale, carbonaceous, contains brackish-water shells	30	
Coal, lustrous and well jointed	1	2
Clay, dark gray, with fossil shells	3	
Sandstone, massive gray, persistent	18	
Clay, carbonaceous.		

An ash determination of an outcrop sample from the coal in this exposure gave 19.16 per cent of ash on the air-dried basis.

Two miles northeast of locality 11, in the SE ¼ sec. 24 of the same township, the bed contains 4 feet of coaly shale and can be traced in detail along the steep banks above Cut Bank Creek. Just west of the town of Cut Bank there are several exposures of the bed, but it is everywhere too dirty to be valuable as a fuel. These exposures occur (1) half a mile southwest of Cut Bank, at the top of the bluff above the creek, where the thickness is 3 feet; (2) near the top of a butte in the center of sec. 11, T. 33 N., R. 6 W., where 2 feet of dirty coal lies immediately beneath a fossil oyster bed; and (3) in a cut on the south side of the railway track in the NW. ¼ of the same section, where there is 2½ feet of coaly shale.

Between the point where the Great Northern Railway crosses Cut Bank Creek and the mouth of Big Rocky Coulee outcrops of the same dirty coal bed can be seen in every mile of the distance at altitudes which, because of the slight inclination of the strata, range only between 3,710 and 3,750 feet. The fossil shells already noted in connection with several outcrops of the bed seem to be generally present here and aid in identifying the horizon.

At locality 12, in the NW. ¼ sec. 28, T. 34 N., R. 6 W., the bed crops out at an altitude of 3,720 feet, about 30 feet above the creek, as a dark band that can be followed for a short distance, dipping gently westward, or upstream. A section at this point, containing over 6 feet of black, coaly material is as follows:

Section of coal bed at locality 12, in the NW. ¼ sec. 28, T. 34 N., R. 6 W.

	Ft.	in.
Shale, coaly	2+	
Coal, clean and well jointed	1	2
Shale, coaly	3	0
Sandstone, gray, massive	20+	

Half a mile upstream, at locality 13, in the NE. ¼ sec. 29, the bed crops out on both sides of the creek only a few feet above water level. On the north side of the creek, close to the line between secs. 29 and 20, the bed has been opened by a short entry made by A. E. Allison, and also in a strip pit paralleling the outcrop for some distance. The coal that is being worked occurs 5 feet above the base of a 25-foot zone of carbonaceous shale lying upon the massive gray sandstone member noted at locality 12. Brackish-water shells are abundant in the carbonaceous shale. The bed of coal that is mined is the thickest of a number of coaly layers occurring throughout the shale zone. It is 1 foot 10 inches thick and on the whole is very dirty, although there are clean streaks of hard, lustrous coal in the bed. It has conspicuous joint planes and weathers out in cubic fragments. Approximate analysis of a sample cut from a fresh face of coal that was somewhat weathered is given as No. 12494 in the table on page 138.

The analysis shows that on the air-dried basis this coal contains about one-third of its weight in ash, thus forcing its heating value below 9,000 British thermal units, although the heating value of 13,510 British thermal units on the moisture and ash free basis shows that the actual fuel value of this coal is about the same as that of the coal from the Valier field. Attempts to market the fuel from this prospect at Cut Bank were unsuccessful, doubtless owing to the high ash content. An attempt was also made to use the coal on a steam plow tractor belonging to the Office of Indian Affairs, but it was given up after a single day's trial.

The slight westward dip carries the coal at the Allison prospect to creek level within a quarter of a mile upstream. One mile farther north, however, on the sharp bend of the creek in the N. ½ sec. 20, the coaly shale zone with brackish-water shells and several beds of impure coal as much as 3 feet in thickness can be seen close to water level. The shale zone is about 35 feet thick and can be followed along the banks of the creek to, and a short distance above, the mouth of Little Rocky Coulee, where the dip of the strata finally carries it beneath the creek.

The general northward strike of the rocks carries the outcrop of the coaly shale zone containing the coal bed mined at the Allison prospect northward across the area lying between Big Rocky and Little Rocky coulees, but it is nowhere exposed in this tract because of the cover of clay and sand of the glacial drift. On Big Rocky Coulee, however, at locality 14, in sec. 17, T. 35 N., R. 6 W., a coaly shale zone that is with little doubt at the same horizon in the Two Medicine formation is again exposed and can be traced eastward about 5 miles, as far as Headlight Butte, in the adjoining township.

Section of coaly shale zone at locality 14, in the NW. ¼ sec. 17, T. 35 N., R. 6 W.

	Ft.	in.
Clay, gray, with 2-foot oyster bed near the base	20+	
Shale, carbonaceous		6
Clay, gray	5	0
Sandstone and shale, interbedded and containing coaly layers.	2	0
Clay, gray	10	0
Shale, carbonaceous, fissile, with many fragments of clean coal, is sandy in places	4	0
Sandstone, massive, gray, and coarse grained	6+	
Bed of creek.		

Three miles northeast of locality 14 the same beds crop out along the sides of the coulee in the E. ½ sec. 3, T. 35 N., R. 6 W. At this point the coaly shale bed is 4 feet thick, contains brackish-water shells, and is overlain by 7 feet of gray slabby sandstone. On Headlight Butte, near the center of sec. 18, T. 35 N., R. 5 W., the same bed crops out near the top of the butte and contains 3 feet of fissile, coaly shale beneath a thick bed of massive cross-bedded sandstone.

COAL AT TOP OF "THE RIM."

The eastward-facing escarpment locally known as "the rim," extending northward from the Great Northern Railway near Ethridge to the Canadian line, is made up of the Virgelle sandstone. The top of this sandstone escarpment was carefully examined for signs of coal, because the workable coal bed in the Valier field on Birch Creek occurs immediately above this formation in the basal beds of the Two Medicine formation. On the lower part of Cut Bank Creek no coal was found at this position. Northward from the latter locality for 20 miles, of which 12 miles lies along the top of "the rim," the basal beds of the Two Medicine formation are everywhere concealed beneath a thick cover of glacial drift. In the northern part of T. 35 N., R. 4 W., however, they are well exposed at the upper ends of a number of coulees that have cut back into the escarpment. Exposures of thin coal in this vicinity are as follows: (1) In the NE. ¼ sec. 10, T. 35 N., R. 4 W., 3 feet above the top of the Virgelle sandstone, 4 inches of dirty coal; (2) in the center of sec. 1, T. 35 N., R. 4 W., 4 feet above the Virgelle sandstone, 6 inches of dirty coal; (3) at locality 15, in the SE. ¼ sec. 18, T. 35 N., R. 3 W., 3 feet above the Virgelle sandstone, 9 inches of dirty coal, exposed for one-third of a mile along the top of the escarpment. Northward from locality 15 to the Canadian boundary no further signs of coal were found, a thick cover of glacial drift concealing the beds of this horizon at nearly all points.

COAL IN THE VICINITY OF LANDSLIDE BUTTE.

In the vicinity of Landslide Butte, the most prominent landmark in the eastern half of the area here described, there are outcrops of a thin coal bed in Tps. 36 and 37 N., R. 8 W., extending several miles both north and south of the butte. This coal bed lies at the top of the Two Medicine formation, immediately beneath the dark-gray Bearpaw shale, which makes the upper 300 feet of Landslide Butte. The coal is too thin to be of value but is of interest because it occurs at the same horizon in the Upper Cretaceous rocks as the valuable coal that has been extensively mined 55 miles to the north, at Lethbridge, Alberta. At Lethbridge the coal lies at the base of the dark marine clay shale called Pierre shale by Dawson.[1] This marine shale has been traced continuously along the outcrop into the area mapped in the vicinity of Landslide Butte as Bearpaw shale, so that the identity of the two formations is unquestionable. Southward from Lethbridge, where the coal is nearly 6 feet thick, coal at this horizon crops out at intervals but gradually becomes thinner until, on Milk River Ridge, 20 miles north of the international boundary line, the bed measures only 1 foot 6 inches.[1] From this locality to Landslide Butte no signs of coal have been reported, probably because for most of the distance the rocks are deeply covered with glacial drift.

On Landslide Butte, at locality 16, in the SW. ¼ sec. 32, T. 37 N., R. 8 W., the following section is exposed:

Section of coal at top of Two Medicine formation in the SW. ¼ sec. 32, T. 37 N., R. 8 W.

	Ft.	in.
Sandstone, gray, slabby	2+	
Coal, clean and hard, breaking out in lustrous cubic masses.		6
Coal, very dirty		7
Coal, clean		1
Clay, dark gray.		

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[1] Dawson, G. M., Report on the region in the vicinity of Bow and Belly rivers: Canada Geol. Survey Rept. Progress, 1882-1884, p. 70c.

Traced down the coulee from locality 16 the outcrop of this bed is practically continuous for 2 miles along both sides of the coulee just above the steep badland slopes cut in the soft light-colored clay of the Two Medicine formation. At locality 17, in the SE. ¼ sec. 33, T. 37 N., R. 8 W., the bed is 4½ feet thick but is all very shaly and impure, containing only a few streaks of clean coal. From this exposure the outcrop of the beds at this horizon around the east slopes of Landslide Butte and to the south is much covered because of the soft nature of the overlying Bearpaw shale, and no coal was seen. In the SE. ¼ sec. 5, T. 36 N., R. 8 W., the same coal bed is exposed in the coulee running southwestward from Landslide Butte. This exposure is west of and down the dip from the main outcrop, and is brought to the surface in an elliptical outcrop near the bottom of the coulee by a slight flexure in the strata. A section on the best-exposed portion of this outcrop is as follows:

Section of coal at locality 18, in the SE. ¼ sec. 5, T. 36 N., R. 8 W.

	Ft.	In.
Clay, gray	2+	
Coal, shaly and impure	1	2
Coal, clean and well jointed, lustrous	1	0
Coal, very dirty, practically a coaly shale	2	10
Sandstone, gray	3+	

Several entries, one of which is at least 100 feet in length, were driven on the bed at this point but were abandoned because of the impure nature of the coal.

Five miles southwest of Landslide Butte, on the south side of the coulee, in the N. ½ sec. 32, T. 36 N., R. 8 W., the bloom of a thin coaly shale bed at this horizon can be followed for a short distance. South of this locality the beds at this horizon were examined at many points as far as Birch Creek about 50 miles distant, but at no place were any indications of coal found.

COAL IN ST. MARY RIVER FORMATION.

Coal occurs at two horizons in the St. Mary River formation. The lower bed is at the base of the formation immediately above the Horsethief sandstone and contains coal of commercial value near the north edge of the area. The upper bed is near the top of the formation and occurs at one locality only.

The lower coal crops out at intervals along R. 9 W. entirely across the area mapped, extending from Birch Creek to the Canadian boundary. The coal is generally too thin to be of value as a commercial fuel, but its frequent occurrence over so extensive a belt of outcrop is of interest because it affords proof of widespread though transient coal-forming conditions at a stage immediately following the deposition of the Horsethief sandstone. The following coal outcrops at this horizon were found between Birch Creek, in T. 29 N., R. 9 W., and Horsethief Ridge, near the center of T. 35 N., R. 9 W.: (1) At locality 19, in the SE. ¼ sec. 21, T. 29 N., R. 9 W., 11 inches of clean, lustrous coal above 6 inches of coaly shale, exposed for half a mile along Blacktail Creek: (2) in the SE. ¼ sec. 34, T. 30 N., R. 9 W., at locality 20, near the head of the coulee leading northeastward to Fourhorns Lake, 8 inches of coal, from which there is a strong seepage of water for a quarter of a mile on both sides of the coulee; (3) at locality 21, at the head of the box canyon at the lower end of Spring Creek (see section below); (4) 1½ miles above the mouth of Trail Coulee, making a bloom for several hundred feet on the north side of the coulee, at locality 22, in the NW. ¼ sec. 29, T. 34 N., R. 9 W., 5 feet of very dirty coal or coaly shale, containing streaks of clean coal; (5) at locality 23, in the NW. ¼ sec. 17, T. 34 N., R. 9 W., 4 feet of dirty coal, making an extensive bloom along the east bank of Cabelle Coulee, 2 miles west of Rim Rock Butte; (6) on the north side of Horsethief Ridge, just above cliffs of Horsethief sandstone, at locality 24, in the SE. ¼ sec. 14, T. 35 N., R. 9 W., 1 foot of dirty coal.

The section at locality 21 is as follows:

Section of coal at locality 21, in the NW. ¼ sec. 32, T. 32 N., R. 9 W.

	Ft.	in.
Sandstone, with ferruginous concretions	8	
Coal, clean and lustrous		9
Coal, very dirty and shaly		7
Shale, dark gray		9
Sandstone, massive and gray, massive member of Horsethief sandstone	10+	

Continuing northward the next outcrops were found in the vicinity of Croff's ranch, in the southwestern part of T. 37 N., R. 9 W., where there are two exposures of coal about 3 miles apart, upon what is probably a continuous bed, averaging 2 feet thick, at the base of the St. Mary River formation. About 500 feet north of the south quarter corner of sec. 31 in this township coal crops out in a cut bank on the east side of Milk River, where the section is as follows:

Section of coal at base of St. Mary River formation at locality 25, in sec. 31, T. 37 N., R. 9 W.

	Ft.	in.
Clay, bluish, blocky		6
Shale, coaly		10
Clay, bluish, blocky	2	
Coal, containing ½-inch lustrous bands, well jointed but somewhat dirty	2	2
Clay, bluish		10
Sandstone, gray and slabby, upper part of Horsethief sandstone.	12+	
Water level of Milk River.		

In the NE. ¼ sec. 6, T. 36 N., R. 9 W., 1 mile southeast of locality 25, the same coal bed makes a bloom extending in a northwesterly direction for over 1,000 feet. The exposure is not good, however, and no measurement of the bed was made.

Northward from locality 25 there are no indications of coal on the grassy slopes at the base of the St. Mary River formation until Coal Coulee is reached, in the NW. ¼ sec. 20. Here, at locality 26, on the northeast side of the coulee, the outcrop of the coal bed can be traced for a quarter of a mile along the steep slopes until the bloom and indications of coal smut are lost on the more gentle grassy slopes. At the mouth of a short entry, badly caved at the time it was examined, the bed measures 1 foot 10 inches, without a parting. The coal was badly weathered and hence judgment as to its quality is uncertain. It very probably contains a considerable percentage of ash. About a mile southeast of locality 26, in the same land section but on the opposite side of Milk River, an isolated area of this bed occurs at the top of the escarpment made by the Horsethief sandstone. Smut from this coal is present over an area of several acres at this locality but there is no cover over the bed and the material is valueless as fuel.

Coal from the upper horizon in the St. Mary River formation is present on the North Fork of Milk River where it crosses the international boundary line. On the west bank of the stream, about 1,500 feet north of the line, coal at this horizon, which has been opened by a short prospect entry, is excellently exposed for a quarter of a mile along the river bank. A section of the rocks at this point is given below:

Section of coal-bearing rocks near top of St. Mary River formation, at locality 27, 1,500 feet north of the north quarter corner of sec. 1, T. 37 N., R. 11 W.

	Ft.	in.
Sandstone, gray	12	0
Clay shale, bluish gray	4	0
Coal		10
Clay shale, gray	3	0
Clay shale, bright green	15	0
Sandstone, gray	5	0
Water level of river.		

These strata dip very gently upstream, so that the coal bed is carried under the water level of the river about 1,000 feet south of the boundary. Toward the south this horizon, near the contact of St. Mary River and Willow Creek formations, can be followed for about 24 miles, almost to Cut Bank Creek, but no further indications of coal were found.

COAL IN THE BELT OF DISTURBED ROCKS.

BLACKFEET COAL FIELD.

The Blackfeet coal field lies in the northwestern part of the Blackfeet Indian Reservation, between Greasewood Creek and the Middle Fork of Milk River, in Rs. 11 and 12 W., and comprises an area 12 miles long and 1 mile wide. This tract is named the Blackfeet field in this report for convenience of description. Its coal has been mined only to a slight extent because of its occurrence on an Indian reservation, and very little information concerning it is available. Because of the lack of development, it is impossible to make more than a rough estimate of the amount of coal in the field, but to judge from the extent of the beds along the outcrop, it seems probable that there is at least 5 square miles of land in this field which is underlain by bituminous coal that could be mined commercially.

The coal-bearing rocks in this field are in the belt of disturbed rocks adjacent to the Rocky Mountains. They are much folded and somewhat faulted, the coal being for the most part in a narrow syncline trending northwest, lying between two anticlinal folds, which bring the Horsethief sandstone to the surface. On the west, across the entire length of the field, this structure is cut off abruptly by a reverse fault, which has carried the rocks of the Two Medicine formation against the Horsethief sandstone and thus limits the field in that direction. On the east the steeply dipping rocks of the St. Mary River formation, with the coal horizon at their base, lie in regular succession above the eastward-dipping Horsethief sandstone, but the steep dip of the strata soon carries the coal beyond minable depth, thus limiting the field on the east. Compared with the simple structure in the Valier field, with its nearly horizontal strata, the lay of the strata in the Blackfeet field is relatively complex, and successful mining of the coal will depend largely upon a knowledge of the geology of the field.

All the coal in the Blackfeet field occurs at the base of the St. Mary River formation, immediately above the Horsethief sandstone. Coal at this horizon has already been described as occurring in the area of nearly horizontal rocks at the Croff ranch and elsewhere to the south. In the Blackfeet field the Horsethief sandstone is of great importance as a marker, aiding in the location of the coal outcrop. At every point where there are natural exposures of the coal they occur at the sides of and parallel to ridges of this sandstone, which are often the only rock outcrops in sight. These ridges are from 5 to 50 feet in height, depending on the dip of the strata and the position with reference to relief and are composed of the coarse gray sandstone of the upper portion of the formation, which weathers buff, with rusty-brown ferruginous bands in places. Fossil oysters of two extinct species, *Ostrea subtrigonalis*, and *O. glabra*, both in beds and as individuals scattered through the massive sandstone, are abundant, which is characteristic of this sandstone in this region. A detailed section on the South Fork of Milk River near the center of the field is as follows:

Section of coal-bearing rocks at locality 31, at base of St. Mary River formation, on east flank of ridge of Horsethief sandstone, in the SE. ¼ sec. 18, T. 35 N., R. 11 W.

	Ft.	in.
Clay, greenish gray.		
Coal		6
Shale, carbonaceous	2	0
Sandstone, gray and platy	1	0
Clay, yellowish	2	0
Coal, clean and lustrous	2	4
Clay, greenish gray		8
Sandstone, gray, platy	9	0
Clay, gray		2
Coal, clean and lustrous	1	10
Clay, carbonaceous	1	0
Sandstone, massive member of Horsethief sandstone	20+	

Two coal beds of importance were seen at only one other point in the field, but in general the exposures are poor and it is not improbable that two beds are everywhere present.

A low strike ridge of Horsethief sandstone crops out entirely across the SW. ¼ sec. 15, T. 34 N., R. 11 W., and can be followed northwestward for several miles. At locality 28, where the strike is N. 22° W. and the dip 62° SW., a strong coal bloom occurs on the west side of this ridge, just above the top of the Horsethief sandstone, and can be traced parallel with the ridge for about 1,500 feet northwestward. A trench dug across this coal bloom revealed 3 feet 6 inches of coal lying between a clay roof and floor. Even on the weathered outcrop the coal appeared clean and lustrous, with a fine cubic grain and no parting. It is the thickest bed of coal so far found in the field and is very probably of as good grade as that mined at the Stone ranch on the Middle Fork of Milk River. The outcrop described lies on the east limb of a syncline of the St. Mary River formation, which is paralleled on each side by a narrow anticline, bringing the Horsethief sandstone to the surface. Northwestward along these folds the next indications of coal are found about 2 miles distant, in the NE. ¼ sec. 9 of the same township. Here, above the Horsethief sandstone and dipping about 35° E., there are faint indications of coal bloom for several hundred feet parallel to the sandstone outcrops. About half a mile northwest of these exposures, at locality 29, in the SE. ¼ sec. 5, the same bed crops out along the west limb of the syncline above mentioned. The coal makes a strong bloom for 500 feet, paralleling the outcrops of the

Horsethief sandstone, which strike N. 23° W. and dip 30° NE. The bed is over 2 feet 6 inches thick, and rests on a floor of gray clay. The roof of the coal could not be reached by a shallow trench because of the thickness of the slope wash, and the full thickness of the bed at this point is therefore not known. The coal is lustrous and clean and the portion of the bed seen contains no parting. At locality 30, in the NW. ¼ sec. 4, the coal bed is again exposed, dipping eastward along the flank of the anticline on the east edge of the field. The dip of the bed parallels the slope of the ground wherever the coal is exposed at this point, and the surface is therefore covered with a thick layer of coal smut over many acres, but it is very difficult to estimate the thickness of the bed. To estimate the true thickness from the layer of weathered coal on this dip slope, the bed is probably over 2 feet thick.

Localities 29 and 30, just mentioned, are on the south slope of Milk River Ridge, which forms the divide between Milk River and Cut Bank Creek. The surface of this "ridge" is a smooth plain, covered with a veneer of gravel, which completely obscures all signs of the underlying bedrock formations. There is therefore a covered area several miles long in this part of the Blackfeet coal field, but because of the fact that coal is present at the next good exposures to the north, it is not improbable that at least a part of this covered area is coal land. On the north side of Milk River Ridge, sloping toward Milk River, a folded structure similar to that on the south side of the ridge and on the same line of strike exposes the Horsethief sandstone and the St. Mary River formation. At locality 31, a quarter of a mile south of the river, in the SE. ¼ sec. 18, T. 35 N., R. 11 W., the coal bed is well exposed along the east limb of the anticline on the east edge of the field, where it strikes N. 18° W. and dips 48° NE. The complete section of the rocks at this point has already been given (p. 149). There are two coal beds present, separated by 10 feet of sandstone and clay. Both of the coals crop out in an almost continuous bloom for 1,000 feet parallel to the ridge of Horsethief sandstone. The upper bed—that is, the one lying to the east—is 2 feet 4 inches thick, and the lower bed 1 foot 10 inches. The coal in each of the beds appears to be of the same grade. It weathers out in fine irregular fragments, which on being freshly broken show faces of clean, lustrous coal. No parting is present in either of the beds, and the material seems to be identical with that in the southern part of the field already described.

On the north side of the valley of Milk River the two parallel anticlines with an intervening syncline in the Horsethief sandstone and the St. Mary River formation, which have so far been characteristic of the coal field, still continue, except that the plane of the reverse fault on the west side of the field here cuts off a part and in places even the crest of the west anticline. Two miles northwest of locality 31 an extended coal bloom shows in the northwest corner of sec. 7, T. 35 N., R. 11 W., at locality 32. It can be traced almost continuously for over a mile northwestward. The outcrop occurs just above the eastward-dipping Horsethief sandstone, and has a strike of N. 22° W. and a dip varying between 40° and 53° NE. At locality 32, on the south end of this outcrop, a trench across the coal bloom exposed 1 foot 6 inches of clean, lustrous coal. At the north end of this outcrop, at locality 33, a pit had been dug, exposing the coal, but was refilled. The writer was informed by a resident of the region who took part in this prospecting that the coal measured 2 feet in thickness.

Between locality 33 and the Middle Fork of Milk River .the gravel of a smooth high-level plain, similar to Milk River Ridge and at the same altitude, obscures the underlying bedrock formations. Immediately north of this plain, on the slopes leading down to the Middle Fork of Milk River at the Stone ranch, the east anticline of two that extend throughout the length of the Blackfeet field exposes the Horsethief sandstone in two parallel strike ridges lying on the limbs of the fold. West of the anticline there is a syncline containing the lower part of the St. Mary River formation, exposing on its west limb the upper massive member of the Horsethief sandstone. The lower part of the Horsethief sandstone is cut off by the reverse fault, which has already been described as the boundary of the coal field on the west, and which brings the Two Medicine formation up against the younger rocks containing the coal. The folded structure thus brings the Horsethief sandstone and the coal above it to the surface in three parallel lines of outcrop, marked by low ridges of sandstone. Coal crops out along all three of these ridges.

At locality 34, about 1 mile southwest of the Stone ranch, on the west limb of the syncline above mentioned, a prospect entry driven by J. M. Stone along the strike of the coal bed, about 60 feet long in 1911, was the only opening made in the coal of the Blackfeet field up to that time. This coal has been mined by Mr. Stone for his own use for many years. The bed has no parting and ranges from 2 feet 6 inches to 2 feet 10 inches in thickness. It strikes N. 25° W. and dips 40° NE. An analysis is given on page 138 (No. 12602). The roof is a compact gray clay shale, which stands fairly well and is overlain by gray sandstone. The floor is gray clay. Fresh coal from this opening is lustrous and clean, the only impurity visible being minute flakes of iron pyrite that are abundant on smooth faces of the coal. The coal is much jointed, but the joints are irregular and closely spaced and do not stand normal to the bedding. Their attitude and also a fine irregular grain in the coal show the effects of rotational strain, or torsion incident to the folding of the rocks, and contrast strongly with the rectangular jointing normal to the bedding which is present in the nearly horizontal coal beds in the region to the east. Highly polished slickensided surfaces, with a few concentric pressure ridges, simulating conchoidal fracture, are further evidence of the deformation undergone by the coal. Minute spherulitic markings on small fracture surfaces are probably produced in the same way. The crushed condition of this coal makes it easy to work down with the pick, but even when carefully mined in this manner it produces a large percentage of fine coal.

About three-fourths of a mile northeast of locality 34, on the opposite side of the syncline, the same coal crops out at locality 35, where it strikes N. 26° W. and dips 44° SW. Here, about 100 feet east of the southwest corner stone of section 25, T. 36 N., R. 12 W., the bloom of two coal beds lying about 10 feet apart can be traced along the outcrop, lying parallel to a prominent strike ridge of gray sandstone. Entries were driven by Mr. Stone on both of these beds where they crop out on the cut bank on the south side of the river, 1,000 feet to the north. At the time they were examined by the writer these openings were completely blocked by slumping. Mr. Stone reported that the lower bed—that is, the one lying to the east—was 10 inches thick, and the upper bed 2 feet thick. At locality 36, on the side of the anticline opposite locality 35 and a short distance south of the Stone ranch, the coal crops out with a dip of 65° NE. and a strike of N. 10° W. A shallow open cut exposes the following section:

Section of coal bed near Stone ranch, at locality 36, in the SW. ¼ sec. 25, T. 36 N., R. 12 W.

	Ft.	in.
Sandstone, gray.		
Coal, much weathered and very dirty		7
Clay		1
Coal, weathered and dirty	1	4
Clay, gray.		
Thickness of bed	2	0
Thickness of coal	1	11

The bed is probably the same as the upper one at locality 35. The outcrop is much obscured by soil creep, which makes it difficult to pass judgment on the quality of the coal.

It is not possible to determine the quality of the coal in a bed by examining only its surface outcrop. The prospect at the Stone ranch is the only place where fresh, unweathered coal could be obtained from the Blackfeet field, so that an estimate of the grade of the fuel is necessarily based on this single locality. It is very probable, however, that except for variations in the ash content, the coal is fairly constant in quality throughout the field, for it occurs at a single geologic horizon and has everywhere been subject to about the same amount of deformation. A sample from the Stone prospect, at locality 34, carefully prepared according to the standards in use by the United States Geological Survey, gave analysis 12602 on page 138.

On comparing this analysis with that of coal from the Valier field it is evident that chemically the two fuels are very much alike. The deformation of the strata in the Blackfeet field has apparently raised the grade of the coal to only a very slight extent. The percentage of carbon in the fuel as given by the analysis on the moisture and ash free basis is 79 for the Blackfeet field and 76 for the Valier field. The moisture in the air-dried coal is 5.8 per cent for the former and 5.3 per cent for the latter. Oxygen on the same basis is 15.32 per cent in the Blackfeet coal and 15.07 per cent in the Valier coal. The ash content is slightly lower than in the Valier coal, being 12.73 per cent compared with 14.07 per cent.

The heating value of the coal from the two fields is also nearly the same. Air-dried coal from the Blackfeet field gave 11,310 British thermal units and that from the Valier field 11,070 British thermal units. The average of a number of samples of coal from the Lethbridge field, in Alberta, gave 11,200 British thermal units on the same basis; and from the Great Falls field 11,040 British thermal units.

The jointed and fractured nature of the coal bed in the Stone prospect has already been mentioned. This feature was observed in this locality only, but it is very probable that the coal will be found in a similar compressed and broken condition throughout the Blackfeet field. This will cause a high percentage of fine coal in the production of this field, and lumps of coal above 4 or 5 inches in greatest dimension will be unusual. The fuel, however, withstands weathering very well and does slack even after long exposure. This ability to withstand weathering, together with the jointing in the coal and its close chemical affinity to coals in Alberta and Canada long regarded as bituminous, seems to place the coal of the Blackfeet field in the bituminous class.

MINOR OCCURRENCES OF COAL IN THE BELT OF DISTURBED ROCKS.

All the geologic formations present in the area of nearly horizontal rocks in the eastern part of the region under discussion also occur in the belt of disturbed rocks. It is thus evident that the beds at the horizons of the coal-bearing strata in the area of nearly horizontal rocks are to be found in the disturbed belt and must be considered as possibly coal bearing there. There are many scattered outcrops of coal in this belt, from the Canadian boundary to the south side of the area mapped. Outside of the Blackfeet coal field, however, every occurrence of coal found in this belt is so much disturbed by folding and faulting that even where there is coal of a thickness that might be worked, the quantity is too small or uncertain to warrant development. Beginning at the north end of the disturbed belt, these scattered outcrops of coal will be described in the order they are passed in traveling southward across the field.

At locality 37, on the crest of the north-south ridge near the center of the SW. ¼ sec. 29, T. 37 N., R. 12 W., 1 foot 1 inch of clean, well-jointed coal shows in strata that have been much disturbed. This coal is at the top of the Two Medicine formation. About 50 feet of the overlying Bearpaw shale is exposed here, but is cut off by a fault on the west.

At locality 38, near the center of sec. 8, T. 37 N., R. 13 W., coal which crops out on the west bank of St. Mary River has been opened by a group of small workings, locally known as the Paisley mine. These openings were badly caved and inaccessible at the time of the examination, but a prospect pit sunk about 5 feet on the outcrop of the bed gave the following section. The strike is N. 20° W. and the dip 60° SW.:

Section at Paisley prospect, on St. Mary River, in sec. 8, T. 37 N., R. 13 W.

	Ft.	In.
Clay, gray.		
Coal, clean and somewhat lustrous, bedding planes only faintly shown, crushed to some extent, best coal in the bed.		10
Coal, more dirty than upper bench, much crushed and distorted, no well-marked bedding or joint planes; crumbles to a powdered mass	3	10
Clay shale, dark gray.		

To judge from the crushed condition of the lower bench of this bed, it is not improbable that it has been thickened by shearing, being thrust upon itself. Such action on a larger scale has in many places duplicated entire formations in the disturbed belt. If this is true, the coal is apt to be very pockety and irregular in thickness. In 1906 M. R. Campbell obtained a sample of coal from this mine, the analysis of which is given as No. 3934 on page 138. The coal was not in place, and the sample consisted of lumps gathered from a mass that had fallen from the face.

About a thousand feet northwest of the Paisley prospect, on the strike of the bed, a trench 30 feet long and several feet deep was dug in an attempt to locate the extension of the bed. No coal was uncovered by this trench, and it seems safe to say that it has been cut out by faulting. However, a mile farther northwest, in the NW. ¼ sec. 8, the Horsethief sandstone, striking N. 20° W., dipping 50° SW., and containing several oyster beds, crops out as a bold strike ridge on the line of strike of the coal at the prospect. This exposure, taken in connection with a similar ridge of the same formation 2 miles to the southeast, also on the same strike line, suggests that the coal at locality 38 belongs at the base of the St. Mary River formation, lying immediately above this sandstone.

At locality 39, in the NW. ¼ sec. 30, T. 36 N., R. 12 W., coal crops out for several hundred feet above a low ridge of Horsethief sandstone carrying several oyster beds. A trench across this outcrop exposed 14 inches of coal, striking N. 20° W., and dipping 47° SW. About 100 feet west of this outcrop the Horsethief sandstone stands on edge or is overturned, and the entire mass is much broken.

At locality 40, near the center of sec. 16, T. 35 N., R. 12 W., there is a strong coal bloom along the west side of a low ridge of Horsethief sandstone, striking N. 20° W. and dipping 60° SW. At the point where the coal is best exposed this strike ridge turns abruptly eastward and disappears in a much disturbed and broken structure. It is probable that there is a small amount of undisturbed coal here.

At the point where the Browning-Babb stage road crosses Cut Bank Creek, about 4 miles northwest of Browning, at locality 41, coal from the base of the St. Mary River formation crops out on the west side of a ridge of Horsethief sandstone containing the usual oyster shells. There are two thin coal beds at this point, the section being as follows:

Section of coal-bearing rocks on Cut Bank Creek at locality 41, in the NW. ¼ sec. 15, T. 33 N., R. 11 W.

	Ft.	in.
Clay, gray.		
Coal	1	0
Clay, gray	25	0
Coal, much weathered and apparently very dirty	1	4
Clay, gray	10	0
Sandstone, massive gray, Horsethief sandstone	60+	

The lower coal bed of this section has been opened on the south bank of the creek, but the entry was so badly caved as to be inaccessible at the time of the examination. The same bed is also exposed on the north side of the creek, the thickness being about the same as that on the south. Nothing is known of the extension of this coal either north or south of the creek beyond these outcrops, because to the south the bedrock formations are thickly covered by glacial drift, and to the north they are hidden by gravel which covers the plain lying between Greasewood and Cut Bank creeks.

Farther south coal was found as follows: (1) At locality 42, in sec. 34, T. 33 N., R. 10 W., on the south side of the right of way of the Great Northern Railway, just within the boundary of the disturbed belt, 8 inches of coal in gray shale, dipping 10° NE. (2) On Two Medicine Creek, at locality 43, in the NW. ¼ sec. 20, T. 31 N., R. 10 W., 6 inches of lustrous coal in the Two Medicine formation in an 8-foot bed of fissile carbonaceous shale containing fossil shells, striking N. 15° W. and dipping 35° SW. (3) At locality 44, in the NW. ¼ sec.

23, T. 31 N., R. 10 W., coal crops out for 300 feet on the north
Two Medicine Creek, striking N. 17° W. and dipping 60° S
trench dug across this outcrop gave the following section:

*Section of coal bed at locality 44, in the NW. ¼ sec. 23, T. 31 N., R. 10 W., on nort
Two Medicine Creek.*

	Ft.
Shale, carbonaceous, grading into coal below.	
Coal, lustrous, but much crushed, having a foliated appearance	1
Clay, gray.	

The coal in this section is very irregular both in thickness
quality. A few hundred feet north of the point where the
was measured the entire bed seemed to be little better than a
shale.

OIL AND GAS NEAR BASIN, BIG HORN COUNTY, WYOMING.

By Charles T. Lupton.

INTRODUCTION.

The discovery of a high-grade translucent oil and an opaque lubricating oil in what was originally believed to be only a mediocre gas field near Basin, Big Horn County, Wyo., has attracted the attention of engineers and oil operators, and since 1913 considerable drilling has been done in that part of the field where the attitude of the rocks is favorable for the accumulation of oil or gas and the land is not included in the Government reserves. In addition to the oil wells larger gas wells than those previously known have been discovered, the yield of three of which is sufficient to supply Basin and Greybull, towns of about 900 inhabitants each, situated on the Chicago, Burlington & Quincy Railroad about 3 miles west and 8 miles northwest of the field, respectively.

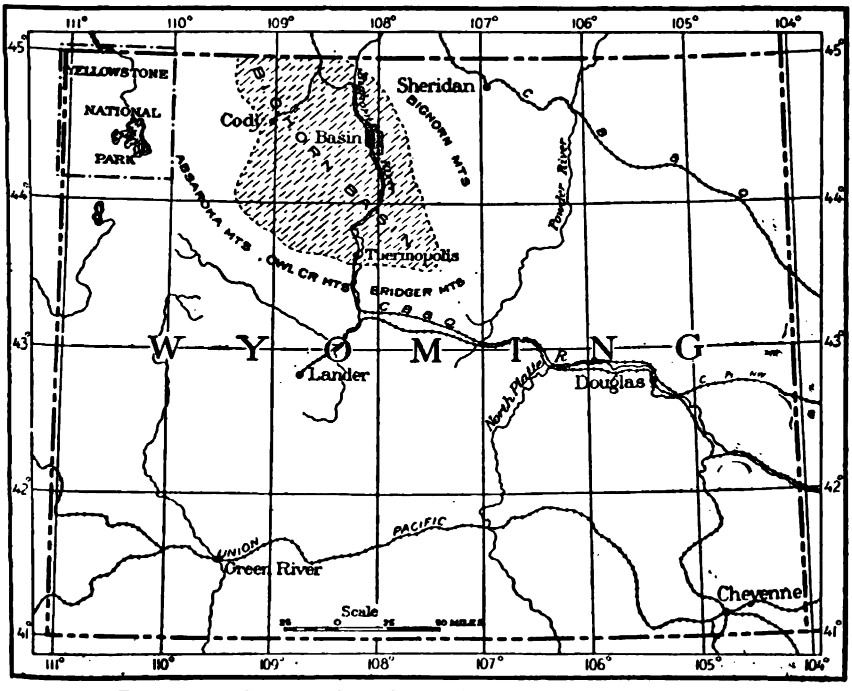

FIGURE 11.—Index map of Wyoming showing position of the Basin oil field.

The object of this report is to assemble all the data available on the field regarding the discovery of oil and gas and to present a map of the geologic structure from which it will be possible to determine the parts of the dome and anticlines that carry oil and gas and thus to separate the productive from the nonproductive areas. This field is only a small part of an extensive belt of similar territory along the foothills of the mountains bordering the Bighorn Basin, in which numerous domes and anticlines, more or less well adapted to the accumulation of oil, may be found. A report soon to be published contains a description of such structural features in the southern part of the Bighorn Basin.

The field herein described includes parts of Tps. 50, 51, and 52 N., Rs. 92 and 93 W. of the sixth principal meridian, and has an area of about 65 square miles. It is situated mainly east of Bighorn River and northeast, east, and southeast of the town of Basin. Plate XVII (p. 178) shows the general geology of the field and Plate XVIII (p. 188) the details of the two principal structural features—the Torchlight dome and Lamb anticline—that are regarded as favorable for the accumulation of oil and gas.

The results herein given have been made more complete by the kindly cooperation of the Greybull Oil Co. and the Big Horn Oil & Gas Co. through their superintendent, Homer T. Lamb, of Greybull, Wyo.; of W. L. Walker, of Basin, Wyo., geologist for the Valentine interests—an unincorporated company; and of A. M. Johnson, president of the Champion Oil Co. The hospitality and assistance of many of the residents of the region aided materially in the field work.

PREVIOUS INVESTIGATIONS.

Petroleum has been known in this general locality since 1884. In 1888 Ricketts,[1] Territorial geologist of Wyoming, described an oil spring near Bonanza, on No Wood Creek, in sec. 26, T. 49 N., R. 91 W., and gave an analysis of the oil. Knight,[2] Eldridge,[3] and Fisher[4] mention this occurrence of oil, and Fisher gives a detailed analysis of it in his report, which covers the greater part of the Bighorn Basin. When the field work for Fisher's report was done, in 1904 and 1905, only one well had been drilled in this field. Regarding this well Fisher states:

> About 3 miles east of Basin, Wyo., a small well is being dug in the Pierre shale for the purpose of finding gas. The present depth of the well is about 100 feet, and an appreciable amount of gas has already been obtained. A small company has been organized and the work will be continued.

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[1] Ricketts, L. D., Report of the Territorial geologist of Wyoming, 1888, pp. 39-40.

[2] Knight, W. C., Wyoming Exper. Sta. Bull. 14, p. 167, 1893.

[3] Eldridge, G. H., A geologic reconnaissance in northwest Wyoming: U. S. Geol. Survey Bull. 119, pp. 64, 65, 1894.

[4] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, p. 59, 1906.

Washburne,[1] while making an examination of the coal in the northeastern part of the Bighorn Basin in 1907, collected information of value regarding the principal folds in this region that may serve as reservoirs for oil and gas. Regarding the two anticlines described in the present report, Washburne says:

> The Torchlight anticline, or "dome," as it is known to the prospectors, is about 3 miles east of Basin, Wyo. The dome is small, being about 1 mile long and one-half mile wide, and forms part of a much larger anticline extending a mile or more to the northwest. The dips of the larger anticline are so gentle that it seems doubtful whether its structure is sufficiently pronounced to favor the accumulation of gas. The small dome, however, must be considered a favorable structural feature. The crest of this little dome is in black shale, probably between sandstones A and B. If such is the case, the gas horizon would be found at a depth of 1,150 or 1,200 feet. This figure is uncertain because there is doubt as to the correlation of the sandstone surrounding the gas field, here designated sandstone B. It is thought to be the same as a sandstone occurring in many places 275 feet above sandstone A.
>
> The Torchlight Drilling & Mining Association (Ltd.), of Basin, Wyo., has two wells on this anticline. Both wells are 2 inches in diameter. Well No. 1 is 106 feet deep. It obtains gas from sandy shale between depths of 15 and 85 feet, with a very strong flow of gas from a thin sandstone at a depth of 60 feet. This sandstone carries water highly charged with bitter salts. The log of well No. 2 is given below. The principal gas horizon of this well is a 30-foot thin-bedded sandstone encountered at a depth of 192 feet. The sandstone is saturated with gas and contains some oil. The pressure of the gas is between 35 and 55 pounds per square inch, so that ordinarily the water in the well, standing 65 feet from the surface, holds the gas quiet, but when the water is pumped out to a depth of 110 feet there is a good flow of gas. Part of this gas is used to supply a 4-horsepower engine and two stoves at the driller's camp.
>
> The soil on the Torchlight dome is in places impregnated with bituminous matter which has escaped from the underlying rocks. An open pit, 8 feet deep, is said to give off a strong odor of ammonia, probably a product of organic decomposition.

Log of well No. 2, Torchlight Drilling & Mining Association, 3 miles east of Basin, Wyo.

[No. 2 on Plate XVIII.]

	Thickness.	Depth.
	Feet.	*Feet.*
Shale, sandy	125	125
Sandstone A, containing "sulphur water, with some soda and iron," traces of gas	35	160
Shale with some sandstone	32	192
Sandstone, thin bedded, containing gas and a little oil	30	222

A well is being drilled for gas by Henry Sherard, of the Union Gas & Oil Co., about 3 miles northeast of Basin, Wyo., near the northwest corner of sec. 11, T. 51 N., R. 93 W. The structure at this locality is that of a very gentle anticlinal flexure on the flanks of a larger anticline that extends from the Peay Hill dome near Greybull to the Torchlight dome, 3 miles east of Basin. The structure can not be thoroughly worked out because of the lack of exposures, but from the tracing of a thin sandstone along the hillside it would seem probable that the well is located on the side of a small minor anticline of domical form. The rocks at the well are not exposed, but from the depth of sandstone B in the well it is probable either that there is a fault between the hillside and the well or that the concealed rocks dip westward at an angle of over 10°.

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[1] Washburne, C. W., Gas fields of the Bighorn Basin, Wyo.: U. S. Geol. Survey Bull. 340, pp. 348-363, 1908.

The possible dome on which this well is located is so small and gentle that it must be regarded as a structure of doubtful favorability for gas. Such a faint structure may indicate a more pronounced dome and a good gas reservoir below, or the structure may die out downward within a short distance and no gas reservoir be present. In the latter case the location of the well, which is on the limb of the larger anticline, would be better for oil or water than for gas, should either exist in commercial quantities. The depth of the Greybull gas horizon at this well is between 1,450 and 1,500 feet.

Log of the Union Gas & Oil Co.'s well No. 1, 3 miles northeast of Basin, Wyo.

[No. 29 on Plate XVIII.]

	Thickness.	Depth.
	Feet.	*Feet.*
Shale, yellowish	6	6
Shale, gray	111	117
Sandstone, light gray, probably sandstone B	43	160
Shale, light gray	37	197
Shale, black, with thin beds of brown fine-grained sandstone containing some gas and oil	22	219
Shale, light gray, with a little grit; small amount of gas and oil	27	246
Shale, sandy, with some gas	79	325
Shale, dark, with some very hard layers	75	400
Shale, gray	41	441
Sandstone, with gas and water; doubtless sandstone A	64	505
Shale, sandy, with a little water	42	547
Shale, dark gray	157	704

This well (No. 29 on Pl. XVIII), according to report, was later drilled to a depth of 1,100 feet, but no oil or gas of economic importance was obtained.[1]

FIELD WORK.

The field work on which this report is based was done in October, 1914. Some additional information regarding development, obtained during the field season of 1915, has been inserted in the proof. Wendell P. Woodring assisted in the mapping, and Henry C. Evans and Millard Massey contributed by assisting in rodding and doing camp work.

A base line 8,200 feet in length, represented on Plates XVII and XVIII by the line A–B, was measured along the track of the Chicago, Burlington & Quincy Railroad a short distance south of Basin, in secs. 27, 28, and 34, T. 51 N., R. 93 W. The altitudes of the stations at the ends of this base line were determined from a United States Geological Survey bench mark situated near the public square in Basin. The ends of the base line were then occupied and flags and prominent topographic and cultural features were located by intersection. The altitude of each located point was determined by means of vertical angles and distances between points. Where such careful triangulation work is done the results are more nearly correct than chained distances, especially if the chaining is done over broken country. The system of triangulation begun as above described was developed over the entire area mapped. Other United States Geological Survey bench marks in sec. 26, T. 51 N., R. 93 W., and sec. 6, T. 50 N., R. 92 W., were located in order to check the altitudes determined by the vertical-angle method. Particular attention was given to determining the locations and altitudes of the mouths of the wells in the Torchlight dome and Lamb anticline, except those drilled by the Union Oil & Gas Co. near the northwest corner of sec. 11, T. 51 N., R. 93 W. (No. 29) and by the Valentine interests in the SE. ¼ NE. ¼ sec. 10 of the same township (No. 28), the locations and altitudes of which were furnished by F. F. Hintze, jr., of the Wyoming Geological Survey. Although the Peay Hill dome is shown on the map, it was not examined and its position is given merely to show its relation to the Torchlight dome and Lamb anticline.

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[1] Since this paper was submitted for publication Bulletin 10 of the Wyoming Geological Survey, entitled "The Basin and Greybull oil and gas fields, Big Horn County, Wyo.," prepared by F. F. Hintze, jr., has been published. Several references to his report, explaining differences in terminology and structure, are made in footnotes in this paper.

In addition to locating the mouths of wells and topographic and cultural features, such as hills and roads, the outcrops of certain lithologic units, such as the Torchlight sandstone member of the Frontier formation[1] (sandstone B of Washburne's classification[2]) and other sandstone beds situated stratigraphically above and below the Torchlight sandstone, were mapped in and about the Torchlight dome. A very dark shale about 350 feet stratigraphically above the top of the Torchlight sandstone was mapped about both the Torchlight dome and the Lamb anticline. (See Pl. XVIII, p. 188.) The sandstone beds referred to are not exposed in the Lamb anticline, so the dark shale was used as a key to the stratigraphy. Altitudes on the outcrops of the several beds, as well as the dips of the strata, were determined in order that structure contours could be drawn. As noted on Plate XVIII and elsewhere in this report the structure contours are drawn on the top of the Greybull sand, or the top sandstone of the Cloverly formation.

LAND SURVEYS.

The earliest land surveys in this area were made along the east boundary of T. 50 N., R. 92 W., in 1882 by W. J. Boland. In the following year the remaining exterior lines and subdivisions of the same township were surveyed by E. La Peire. A few well-marked corners on the west range line were found, but no monument bearing marks was found in the interior of the township. Two corner monuments, probably set by private individuals and intended for the southeast and northwest corners of sec. 16, were found, but they were not exactly in the proper positions as shown by the General Land Office plat.

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[1] The names Torchlight sandstone and Peay sandstone were proposed by Hintze for the sandstones previously called by Washburne sandstone B and sandstone A. As names are much preferred to letters for the designation of oil sands, Hintze's names will be used in this paper.

[2] Washburne, C. W., op. cit., pp. 350, 351.

In 1903 Edward F. Stahle resurveyed the exteriors of T. 52 N., R. 93 W., and in the following year he resubdivided the township. Mr. Stahle also surveyed Tps. 50 and 51 N., R. 93 W., in 1903. A few well-marked corners, indicated on the accompanying maps, were found. That part of the eleventh auxiliary meridian which forms the western boundary of T. 51 N., R. 92 W., was surveyed by Mr. Stahle in 1903. The remaining exterior lines and the subdivisions of this township were surveyed by Wilford W. Utterback in 1912. All the land surveys noted above, except that by Mr. Utterback, who was in the direct employ of the General Land Office, were made under the contract system. The recent work by Mr. Utterback shows that the east-west dimension of the west tier of sections of T. 51 N., R. 92 W., is about one-fourth mile greater than the original survey of that township indicated. This condition suggests that the original survey of the interior of this township was never tied to the west range line. The interior corners and some on the southern township line are marked by iron posts with brass caps, on which are indicated the positions of the corners. All monuments found in other parts of the area are of stone.

HISTORY OF DEVELOPMENT OF THE FIELD.

The first discovery of oil in the eastern part of the Bighorn Basin is believed to have been made in sec. 26, T. 49 N., R. 91 W., near Bonanza post office, on a tributary of No Wood Creek, by Edward Lloyd in 1884. Knight[1] makes the following statement regarding the popularity of this spring:

> One very hard winter in the eighties the supply of kerosene oil gave out in the Bighorn Basin and the crude oil from the Bonanza spring was burned in the lamps by many settlers. It was a very good substitute and has always been highly praised by those who actually used it for illuminating purposes.

A well was begun near the spring in 1888 and drilled to a depth of 1,200 feet. Artesian water was encountered, but no oil or gas. In 1902 a well was drilled in sec. 27, T. 49 N., R. 91 W. As this well was plugged it was believed by the settlers that oil was encountered, but no definite information could be obtained regarding the results.

The existence of the Bonanza oil spring has been an incentive to oil and gas prospectors to make further search for favorable places to drill in this part of the Bighorn Basin, and as a result the first wells were drilled in the Torchlight dome in 1904. In 1907 a well (No. 29, Pl. XVIII) was drilled in the NW. ¼ NW. ¼ sec. 11, T. 51 N., R. 93 W., to a depth of about 1,100 feet, but without encountering oil or gas in commercial quantities. The results obtained at this well gave little encouragement, and no further drilling was done in the Basin field till 1912, when well No. 26, yielding water only, in the SW. ¼ SW. ¼ sec. 35, T. 51 N., R. 92 W., was drilled to a depth of 1,800 feet. In 1913, 1914, and 1915 there was a revival of drilling operations in the Torchlight dome and Lamb anticline, and up to October 10, 1915, 48 wells were drilled, the greater number of which yielded oil or gas in commercial quantities. The outlines of the "pools" underlying the Torchlight dome and Lamb anticline have been determined in part, but further drilling will be necessary to locate them completely. All the wells drilled in 1915 are within proved territory except one, the Cleveland-Wyoming well, which is about 1½ miles west of the Torchlight dome. The table under the heading "Wells drilled" (p. 187) summarizes the general information regarding the development of the field.

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[1] Knight, W. C., and Slosson, E. E., Bonanza, Cottonwood, and Douglas oil fields: Univ. Wyoming Bull., Petroleum series, No. 6, p. 7, 1903.

SURFACE FEATURES.

The Bighorn Basin, of which the area described in this report forms a part, is a broad depression lying between the Bighorn Mountains on the northeast and east, the Owl Creek and Bridger mountains (the latter being that part of the Owl Creek Mountains east of Bighorn River) on the south, and the Absaroka Mountains on the southwest.

The Basin oil field lies in the eastern part of this great depression and has a hilly surface. In elevation it ranges from about 3,800 feet above sea level at the river near Greybull, to about 4,600 feet on the northeast rim of the Lamb anticline, in the NE. ¼ NE. ¼ sec. 1, T. 51 N., R. 93 W. Its principal surface features are the broad valley of Bighorn River in the western part and a rough hilly country lying to the east, which includes the Torchlight dome, the Lamb anticline, and the northwest end of a southeastward-trending anticline of doubtful importance as a reservoir of oil or gas. The immediate valley of Bighorn River is marked by a flood plain, in places 2 or 3 miles wide. A number of remnants of gravel-capped terraces are conspicuous, especially on the west side of the river. They are present at but few places on the east side of the stream, for they have been removed by erosion as the river has gradually changed its course toward the east. No Wood Creek, which joins Bighorn River in sec. 30, T. 50 N., R. 92 W., has gradually changed its course to the south, as is shown by the prominent terrace remnants a mile or more in width lying just north of the present flood plain of that stream.

The hilly portion of the field consists of two parts which have very different topography. The part lying south of the Basin-Hyattville road contains numerous hogback ridges trending northwest, with badland valleys intervening; the part lying north of the road contains smooth, gently rolling hills, with badland topography in places adjacent to stream courses where erosion has been most active. Just east of the river flood plain a prominent escarpment of shale forms the river bluffs, the edge of which is of badland character in many places, and extends through secs. 2, 11, 14, 23, and 26, T. 51 N., R. 93 W. In secs. 24 and 25 of the same township and sec. 19, T. 51 N., R. 92 W., which include the Torchlight dome, cliffs of sandstone 20 to 40 feet in height are conspicuous and in many places form nearly impassable barriers.

The surface of the central part of the Torchlight dome and that of the axis of the Lamb anticline contain irregular basin-like depressions. The central depression in the Torchlight dome is surrounded by two concentric inward-facing walls of sandstone, the outer of which is composed of the Torchlight sandstone, described in this report under "Stratigraphy," and the inner is a bed of sandstone about 100 feet lower. The depression along the axis of the Lamb anticline contains no exposures of the sandstone beds that are so prominent around the Torchlight basin. These topographic basins, being near each other, are both surrounded by an irregular inward-facing wall of shale, the approximate position of which is shown in Plates XVII and XVIII by the line marked "Band of dark shale." Plate XVII shows the relation of the surface features of the Torchlight dome to the geologic formations that crop out in it. The shale walls surrounding the depression representing the Lamb anticline are even more prominent than those that form the rim of the Torchlight basin, but no sandstones occur in that part of the section exposed.

In these areas the lowest part of the surface coincides with the highest part of the dome and the crest of the anticline. This is due to the erosion of the two uplifts by streams, which follow their trend in a general way. These valleys have made it possible to construct good roads with low gradients into both areas at a reasonable expense. The principal minor valleys contain well-traveled roads over which drilling machinery and supplies can be transported with ease.

CLIMATE AND WATER SUPPLY.

The climate of the Bighorn Basin is semiarid. Records of temperature have been kept at Hyattville, 25 miles southeast of Basin, for 11 years or more. During this time the lowest temperature recorded was 32° below zero in January, the maximum 105° above zero in August, and the mean or average 46.3° above zero for the entire year. The temperature variations at Basin have about the same range.

The question of water supply in this locality is one of importance to the oil driller. At no other place in the Bighorn Basin or in the entire State of Wyoming where records of precipitation have been kept for a number of years is the average annual rainfall so low as at Basin. Records kept from 1898 to 1909, inclusive, a period of 12 years, show that the mean annual rainfall is 5.8 inches, which is less than half that recorded at Thermopolis, Dubois, and Lander, and less than one-third of that at Newcastle and Gillette.

The main surface water supply in this area is that furnished by Bighorn River and No Wood Creek, its largest eastern tributary. Each of these streams carries throughout the year an almost inexhaustible supply of excellent water for domestic use. Many of the ranchers and some of the oil companies haul water several miles from the river to their ranches and drilling outfits. All the towns and villages along Bighorn River in northwestern Wyoming derive their water supply from this stream or the lower courses of its principal tributaries.

In the early drilling in the Torchlight dome and Lamb anticline water was pumped from Bighorn River in the vicinity of Basin. The Valentine interests, the Champion Oil Co., and the Cleveland-Wyoming Oil Co., which drilled a few wells in the Torchlight dome, hauled water from the river not only for domestic use but also for use in drilling.

The underground water supply in an oil or gas region is also of great importance, and anyone contemplating drilling in a semiarid region like the Bighorn Basin should carefully consider the probability of obtaining water for domestic use or drilling in the rocks he expects to penetrate. In this field two sands—the Peay and Greybull—yield water in most of the wells drilled, and three others—the Torchlight, Kimball, and Muddy—carry water in some of the wells, as shown by the following table:

Percentage of wells obtaining water in sands in the Basin oil field.

Sand.	Wells penetrating the sand.	Water bearing.	Dry.	Percentage of wells obtaining water.
Torchlight	19	2	17	11
Peay	48	41	7	85
Kimball	41	4	37	10
Muddy	7	2	5	29
Greybull	6	5	1	83

Some of the records are incomplete on this point, so that the percentage of wells encountering water in the Peay sand may be even greater than is indicated above. The best water obtained from all the wells is that from the Peay sand in the Columbia No. well (No. 18 on Pl. XVIII), in the SE. ¼ NE. ¼ sec. 12, T. 51 N R. 93 W. From this well water for domestic use is pumped to th main camp of the Greybull Oil Co., in the SE. ¼ NW. ¼ sec. 24 of th same township. The fact that the Peay and Greybull sands yiel water in most of the wells should be of considerable value to thos prospecting for oil and gas.

STRATIGRAPHY.

PUBLISHED CLASSIFICATIONS.

The stratigraphy of the Cretaceous and Tertiary rocks on the east side of the Bighorn Basin have been discussed in a general way by Eldridge, Fisher, and Washburne. Eldridge[1] recognized the Dakota, Colorado, Montana, Laramie, and Wasatch formations; Fisher[2] divided the Cretaceous system into Morrison, Cloverly, Colorado, Pierre, and Laramie and associated formations and described the Tertiary system as represented by the Wasatch and possibly other Eocene formations; Washburne[3] considered the Cloverly formation to represent the Lower Cretaceous (?), and the Upper Cretaceous to include the Colorado shale, Eagle sandstone, Claggett formation, Judith River formation, Bearpaw shale, and Laramie (?) formation. The Tertiary system he regarded as represented by the Fort Union and Wasatch formations. Hewett,[4] while making an examination of a part of the west side of the basin, measured in detail a thick section (14,500+ feet) on Shoshone River. These rocks, except the lower 1,110 feet, which is included in the Sundance (Jurassic) and the Morrison (Jurassic or Cretaceous), comprise the Cretaceous and Tertiary systems. Hewett divides the Cretaceous into "Cloverly," Colorado, Gebo, Meeteetse, and (possibly) Ilo formations, and the Tertiary into the Fort Union and Wasatch formations.[5]

The accompanying table shows the subdivisions of the Cretaceous and Tertiary systems in the vicinity of Basin, Wyo., as recognized in this report, correlated with the subdivisions adopted by Fisher, Washburne, and Hewett.

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[1] Eldridge, G. H., op. cit., pp. 22-27.

[2] Fisher, C. A., op. cit., p. 8.

[3] Washburne, C. W., Coal fields of the northeast side of the Bighorn Basin, Wyo., and of Bridger, Mont.: U. S. Geol. Survey Bull. 341, p. 167, 1909.

[4] Hewett, D. F., The Shoshone River section, Wyoming: U. S. Geol. Survey Bull. 541, pp. 91, 95-107, 1912.

[5] In a recent report (The Basin and Greybull oil and gas fields, Big Horn County, Wyo.: Wyoming Geol Survey Bull. 10, p. 17, 1915) F. F. Hintze, jr., recognizes the Cloverly, Lower Benton, Upper Benton, Niobrara, Pierre, Eagle, undifferentiated Montana, and Ilo formations.

Lupton (present paper).

System.	tion.	Thickness in feet.	Characteristics.
Quaternary.		0–50±	Alluvium along stream courses and soil covering a large part of the area.
		0–25±	Terrace gravel along No Wood Creek and Bighorn River consisting of fairly well rounded pebbles of sandstone, chert, limestone, and granite.
Tertiary.			
Cretaceous.	tiated Fort nd Lance ns.	1,275±	Yellowish-gray soft sandstone and drab shale, with valuable coal beds.
	formation.	1,200+	Marine sandstones, thick beds of shale, and coal beds of no importance in this field.
		3,360±	Gray and dark shale, sandy at top and base; contains the equivalent of the Niobrara.
	rmation.	565±	Sandstone and shale alternating. Two sands (Peay and Torchlight) are oil, gas, and water bearing.
	le.	160±	Hard, platy grayish shale containing fish scales. Two sands (Kimball and Octh Louie) carry oil and gas.
	is shale.	710±	Soft gray and dark shale, with a sand (Muddy) near middle.
	rmation.	113	Consists of two sands 10 to 30 feet thick separated by 80 feet or more of variegated sandy shale. The upper sand, the Greybull, contains water.

tions of the formations.

CRETACEOUS SYSTEM.

GENERAL SECTION.

The positions of the oil, gas, and water bearing sands in the Cretaceous strata below the Mesaverde formation are shown in the section given below:

Generalized section of strata from the base of the Mesaverde formation to and including the base of the Cloverly formation in the Basin oil field.

		Feet.
Mesaverde formation.		
Cody shale:		
Shale, gray, drab, and dark, sandy at top and base		3,360±
Frontier formation:		
Conglomerate	7	
Sandstone, Torchlight member, part poorly consolidated; carries a little oil, gas, and water	83	
Shale, drab	100	
Sandstone, shaly; contains a hard layer 12 feet thick that carries a little oil and gas	87	
Shale [1]	105±	
Sandstone, Peay member; oil and gas bearing	45	
Shale, sandy, dark; contains bed of bentonite at base	138	
		565±
Mowry shale:		
Shale, hard, platy	40	
Sandstone, Kimball sand of drillers; oil, water, and gas bearing	50	
Shale	45	
Sandstone, Octh Louie sand of drillers; yields a little oil	25±	
		160±
Thermopolis shale:		
Shale, hard; contains lenses of sandstone	230	
Shale, soft, dark	170±	
Sandstone, Muddy sand of drillers; contains a little gas	35±	
Shale, soft, dark	275±	
		710±
Cloverly formation:[2]		
Light-buff or tan-colored sandstone [Greybull sand of drillers]	20	
Maroon clay	4	
Reddish and tan-colored sandy clay	10	
Drab sandy clay	10	
Deep-maroon sandy clay	20	
Hard tan-colored sandstone	3	
Deep-maroon to purple variegated clay	12	
Lenses of maroon sandstone	3	
Deep-maroon sandy clay	20	
Olive-green soft cross-bedded sandstone, with hard layers lying on maroon and drab-gray Morrison shale	11	
		113
		4,908±

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[1] Thickness of strata below the lower part of this shale to the top of the Cloverly was determined by averaging a number of well logs.

[2] The section of the Cloverly is taken from U. S. Geol. Survey Prof. Paper 51, p. 52, 1906.

CLOVERLY FORMATION.

The Cloverly formation is not exposed at any place in this area. It has been penetrated in some of the oil and gas wells, however, and therefore will be briefly considered. At the type locality of the Cloverly formation, near Cloverly, Wyo., about 15 miles northeast of the northern part of this area, the formation, according to N. H. Darton, consists of 113 feet of strata, a detailed section of which is given above. The upper 20 feet of this formation constitutes the Greybull sand, which carries oil and gas in the Greybull field and water in the Lamb anticline and Torchlight dome. According to Darton—

> The Cloverly formation is believed to represent the Lakota sandstone, Fuson formation, and Dakota sandstone of the Black Hills region. * * * On the basis of the above correlation it represents the later deposits of the Lower Cretaceous and the earliest deposits of the Upper Cretaceous.

It is not certain, however, that the Dakota sandstone is represented in the Cloverly formation at its type locality. The only determinable fossils from the Cloverly are a few plants belonging to the Kootenai flora as determined by Knowlton. They were collected on No Wood Creek, 30 miles above its mouth.

Near the southern edge of the Bighorn Basin the lower part of the Cloverly formation is a particularly gritty sandstone, and in places it is finely conglomeratic.

THERMOPOLIS SHALE.

The name Thermopolis shale[1] is here applied to a mass of generally shaly rocks, limited below by the top of the upper sandstone bed of the Cloverly (Greybull sand) and above, also conformably, by the base of the Mowry shale. It is named from the town of Thermopolis in Hot Springs County, near which it is well exposed. It is not exposed in the vicinity of Basin, but sections obtained in drill holes indicate that it is a predominantly dark shale about 700 feet thick and that it contains one or more lenticular beds of sandstone. The Muddy sand, which is well known to oil operators and in places contains a little gas and water, is the most persistent sandstone bed. It ranges from 15 to 55 feet in thickness and lies from 210 to 330 feet above the top of the Greybull sand, or the top of the Cloverly formation. In some of the wells a sandstone bed about 30 feet thick is present about 60 feet above the base of the Thermopolis shale but is of no economic importance. The generalized section given on page 167 shows the position of the Muddy sand in this shale.

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[1] This formation corresponds to that part of the Lower Benton of Hintze's section lying below the Mowry shale.

MOWRY SHALE.

The Mowry shale, named for Mowry Basin, on the east side of the Bighorn Mountains, has been recognized over a broad area from the west side of the Bighorn Basin to the Black Hills and from northern Montana to the Uinta Basin, Utah. Wherever it has been recognized it is characterized by great numbers of fish scales and a remarkable absence of fish bones and vertebræ. It varies in thickness from place to place, being about 160 feet thick in the Basin oil field. Heretofore the Mowry has been considered as a shale member of the Benton or Colorado, but on account of its wide distribution and distinctive character, it is here treated as an independent formation.

The Mowry, like the Thermopolis shale, is not exposed in the Torchlight dome or the Lamb anticline. Records of wells drilled in and near the Torchlight dome and in the vicinity of Greybull indicate that the beds included in this formation are similar in character to the typical Mowry and that they have a thickness of about 160 feet as shown in the general section.

Two sandstones in this shale—the Kimball and Octh Louie sands of the drillers—carry oil and gas. As indicated in the generalized section, the Kimball sand is about 40 feet below the top of the shale and the Octh Louie about 45 feet below the base of the Kimball. The Kimball is the principal oil-bearing sand in the Torchlight dome, and in places it also contains gas and water. In the Lamb anticline, however, it is generally dry, yielding oil in only one well. The Octh Louie sand is known to contain oil in many of the wells in this field. In fact, according to Homer T. Lamb, oil occurs throughout the Mowry shale in the Torchlight dome.

FRONTIER FORMATION.

The Frontier formation consists of about 565 feet of sandstone and shale with beds of bentonite (a hydrous silicate of alumina) ranging from a few inches to 3 or 4 feet in thickness. The upper 325 feet of the formation is exposed in the Torchlight dome, and the character of the lower part, about 240 feet thick, is known from well logs. As may be noted in the subjoined section, the formation is predominantly sandstone. The 12-foot yellowish-gray sandstone bed, which is about 90 feet above the base of the lowest beds exposed in the Torchlight dome, contains in places pieces of fossilized wood. The characteristics and relations of the beds of this formation are given in the following section:

Section of Frontier formation.

[The upper part was measured in the Torchlight dome, and the lower part (generalized) determined from well records in the vicinity. Measurements made in sec. 24, T. 51 N., R. 93 W and sec. 19, T. 51 N., R. 92 W.]

	Feet.
Cody shale.	
Frontier formation.	
Conglomerate, consisting principally of dark chert pebbles ranging in size from sand grains up to 4 inches in diameter.	7
Sandstone, Torchlight; contains some oil, gas, and water:	
Sandstone, very poorly consolidated	11
Sandstone, massive, gray, somewhat cross-bedded	32
Sandstone, gray, yellow, and drab, very poorly consolidated	40
Shale, drab, very sandy at base; contains a few layers of brown iron-stained concretions in the lower part	100
Sandstone; gray; weathers yellow; interbedded with shale.	9
Shale, drab, yellow, and pink, sandy at top	10
Sandstone, gray, soft, massive	4
Sandstone, yellowish gray; contains two or three layers of dark brownish-yellow concretions; vertical veinlets of calcite as much as 6 inches thick bearing north cut the bed; carries a little oil and gas	12
Sandstone, argillaceous, medium bedded, alternating with softer beds of sandstone	15
Sandstone and sandy shale, interbedded, gray and drab; contains a few disklike and spherical concretions	35
Sandstone, yellowish gray, very thin bedded; ledge maker.	2
Shale, dark drab, sandy; contains a few thin beds of sandstone (to bottom of arroyo in Torchlight dome)	48
(Section below generalized from well logs in the region.)	
Shale, dark blue, hard	30±
Shale, white, hard	25±
Sandstone, Peay, white, poorly consolidated; bears oil, gas, and water	45±
Shale, blue and gray, hard	20±
Sandstone, poorly consolidated	20±
Shale, blue	18±
Shale, very sandy	25±
Shale, dark, sandy	55±
Mowry shale.	563±

The name Frontier was first applied by Knight[1] to a well-defined coal-bearing formation of Benton age in Lincoln and Uinta counties, Wyo. As described by Veatch,[2] it has at the type locality a thickness of 2,200 to 2,600 feet. In the mapping of several coal and oil fields in the State it has been found that there is generally a group of sandstone and shale beds in the middle of the Colorado, which is the representative of the Frontier formation of Lincoln County. The individual beds, as well as the group of beds, thin eastward and disappear at about the meridian of Douglas. These beds of sandstone, which contain the most prolific oil-bearing sands of the State, have previously been treated as individual members of the Colorado shale, but now it is proposed to consider them collectively as the Frontier formation and to name individual beds as members of this formation.

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[1] Knight, W. C., Eng. and Min. Jour., vol. 73, pp. 720-723, 1902; Geol. Soc. America Bull., vol. 13, pp. 542-544, 1903.

[2] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: U. S. Geol. Survey Prof. Paper 56, p. 65, 1907.

In the vicinity of the Torchlight dome the Frontier formation includes three sandstones that bear oil, gas, and water. Only one of these, the Peay sand, carries oil in commercial quantities. The value of the Peay and Torchlight sandstones and a sandstone stratigraphically between them as reservoirs for oil and gas is fully discussed under "Occurrence" (pp. 178–181). The Peay and Torchlight sandstones were first named and described by Washburne[1] as sandstones A and B, respectively, in 1908, and his designations have since that time been adopted by drillers in this region, but it is hoped that these names will be replaced by the terms Peay and Torchlight as proposed by Hintze.

CODY SHALE.[2]

The strata lying above the top of the Frontier formation and below the base of the Mesaverde formation consist in the vicinity of Basin of about 3,360 feet of shale with a single sandstone bed near the base and several thin beds of sandstone carrying fossils near the top. This shale is believed to contain not only the upper part of the Colorado group, but at least 1,000 feet of the Montana group, as is indicated by the fossils listed below. Cody, a town in the western part of Bighorn Basin, from which this shale takes its name, is situated on the outcrop of these beds near Shoshone River, where they are well exposed and where Hewett[3] determined the thickness of the formation to be 2,150 feet. This shale, a detailed section of which follows, crops out directly south of the Torchlight dome. The thickness of the predominantly shaly part was calculated from dip readings and the width of the belt of outcrop, whereas the lower 200 feet and the upper 870 feet were measured with the hand level.

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[1] Washburne, C. W., Gas fields of the Bighorn Basin, Wyo.: U. S. Geol. Survey Bull. 340, p. 350, 1908.

[2] This formation includes the Basin (Niobrara) shale and Pierre shale of Hintze's classification.

[3] Hewett, D. F., op. cit., pp. 91, 98, 99.

Section of Cody shale in the southeastern part of T. 51 N., R. 93 W.

	Feet.
Mesaverde formation.	
Cody shale:	
Shale, sandy, yellowish gray, soft	200
Sandstone, yellowish gray, medium bedded, interbedded with very sandy shale	60
Shale, grayish yellow, very sandy	11
Sandstone, gray, thin bedded, ripple marked	1
Shale, dark drab, sandy. (Fossil collection 8918 from the base of this shale)	63
Shale, dark drab; contains concretions of yellowish impure sandy limestone 4 to 7 feet in diameter	20
Shale, dark drab, with a few concretions (4 to 5 feet in diameter) of brown sandstone and yellowish impure limestone in lower part. (Fossil collection 8917 from the base of this shale)	325
Shale, yellowish gray, in lower part very sandy	108
Shale, yellowish gray, thin bedded, soft; fragments slightly warped	8
Shale, yellowish gray, very sandy	20
Sandstone, gray, soft, thin bedded; fragments have curved surfaces when weathered	2
Shale, sandy, yellowish gray; contains lenticular beds 4 to 12 inches thick, of yellowish gray and brown sandstone	30
Sandstone, grayish brown, thin bedded; fragments warped	1
Shale, dark gray and drab, sandy	23
Sandstone, brown, thin bedded, lenticular	1
Shale, bluish drab, with a few thin beds of fossiliferous sandstone and concretions about 200 feet below top. (Fossil collections 8921 and 8922 from this sandstone. Fossil collection 8920 from a stratum of shale about 350 feet above the base)	2, 285
Sandstone, yellowish gray (highest sandstone encircling Torchlight dome)	2
Shale, grayish drab, sandy	110
Poorly exposed, probably soft sandstone and shale, yellowish gray	90±
Frontier formation.	
	3, 360±

Collections of fossils, No. 8922, from the NE. ¼ SW. ¼ sec. 5, T. 50 N., R. 92 W.; No. 8921, from the NW. ¼ NE. ¼ sec. 1, T. 50 N., R. 93 W.; No. 8917, from the SE. ¼ NW. ¼ sec. 35; and No. 8918, from the NE. ¼ SW. ¼ sec. 35, T. 51 N., R. 93 W., from beds near the top of the Cody shale, indicate that the upper 1,000 feet or more of this shale is of Montana age. Lot 8922 was collected from a bed more than 1,000 feet below the base of the Mesaverde and contains the following species, which belong to the Montana fauna: Inoceramus sp. fragment, Lucina sp., *Nautilus dekayi* Morton, *Baculites ovatus* Say, and Scaphites sp. related to *S. hippocrepis* Dekay. Lot 8921, from a bed at the same horizon, contains only one species, *Baculites ovatus* Say?, regarding which T. W. Stanton states: "This species seems to belong to the Montana fauna." Lots 8918 and 8917, from beds at a horizon a short distance below the base of the Mesaverde formation, contain but few species and according to Stanton may belong to either the Montana or Colorado fauna.

Fossil collection 8920, from a stratum about 350 feet above the base of the Cody shale, in the SW. ¼ sec. 7, T. 51 N., R. 92 W., is definitely from the Colorado fauna and is characteristic of the Niobrara formation, which is believed to be represented in the lower part of the beds included in the Cody shale. The species included in this collection are *Ostrea congesta* Conrad, Inoceramus sp., thick shelled, and Scaphites ? sp.

MESAVERDE FORMATION.

The Mesaverde formation, which overlies the Cody shale in apparent conformity, is about 1,200 feet thick and consists principally of sandstone with a minor amount of shale and a little coal. Not enough field work was done in the vicinity of Basin to enable the writer to determine the upper limit of the formation with certainty. Washburne,[1] who extended his work into this region from the north, correlated the sandstone immediately overlying the Cody shale with the Eagle sandstone, which occupies a similar position with regard to the thick mass of shale along Yellowstone River in the vicinity of Billings, Mont., but it is evident that the Eagle sandstone dies out toward the south and that the sandstone overlying the shale in the vicinity of Basin is not the same as the Eagle, for fossils of Montana age have been found in the Basin field more than 1,000 feet below the sandstone called Eagle. In the type locality in northern Montana the Eagle sandstone is the lowermost formation of the Montana group, hence it can not be the same as a sandstone having 1,000 feet of shale of Montana age below it. Washburne's determination of this sandstone as Eagle is therefore in error.

Hewett,[2] working in the vicinity of Cody on the west side of the Bighorn Basin, recognized two prevailingly sandy formations in the general stratigraphic position of the Mesaverde and named them Gebo (lower) and Meeteetse (upper). The thickness of these formations at Cody is greater than that of the beds believed to be Mesaverde in the Basin field.

A few fossils were found in this sandstone in the Basin field. Collection 8919, obtained 65 feet above the base of the sandstone, contains Anomia sp., *Cardium speciosum* M. and H., Tellina sp.,

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[1] Washburne, C. W., Coal fields of the northeast side of the Bighorn Basin, Wyo., and of Bridger, Mont.: U. S. Geol. Survey Bull. 341, pp. 167-169, 1909. F. F. Hintze, jr., of the Wyoming Geological Survey, has evidently combined the classification of Fisher and Washburne, placing the Eagle sandstone above the Pierre shale. This is an impossible relation, for the true Eagle constitutes the base of the Montana group.

[2] Hewett, D. F., op. cit., pp. 91, etc.

Liopistha undata M. and H., and *Mactra formosa* M. and H. T. W. Stanton states that these species are of Montana age, occurring in the Eagle and Claggett and some of them in still higher formations. This evidence might be used in support of Washburne's classification, but it is completely offset by the finding of good Montana fossils in the shale underlying the sandstone.

In the Basin field the Mesaverde formation is not known to contain oil or gas, and for this reason only a general description of it is given.

TERTIARY SYSTEM.

UNDIFFERENTIATED LANCE AND FORT UNION FORMATIONS.

The Mesaverde formation is overlain by a mass of rocks several hundred feet thick that are believed to represent the Lance and Fort Union formations. During the field work no fossils were found in these rocks, and little evidence is at hand regarding the position of the formation boundaries and the thickness of each formation. At least 1,275 feet of beds were measured, and all are considered to be included in the Lance and the lower part of the Fort Union. The Lance formation is classified by the United States Geological Survey as Tertiary (?); the Fort Union formation is of Eocene age.

QUATERNARY SYSTEM.

TERRACE GRAVEL.

Gravel-capped terraces of Quaternary age are conspicuous surface features on the west side of Bighorn River, in the valley of Greybull River, and on the south side of No Wood Creek near its mouth. At the last-named locality terrace remnants at three different levels are present and slope not only toward Bighorn River but also toward No Wood Creek. Along the west side of Bighorn River and along the lower course of Greybull River, in the area represented by Plate XVII (p. 178), terrace remnants of the same age are present. The gravel consists principally of fairly well rounded pebbles of chert, jasper, chalcedony, limestone, and hard sandstone. The fact that the terraces are limited almost entirely to the west side of Bighorn River is due to the gradual eastward migration of this stream, gentle terraced slopes being thus formed on the west side of the river and in general abrupt cliffs on the east side, where undercutting of the banks and cliffs is much more common. These gravel deposits, the lowest of which is about 40 feet above the streams; serve as protectors of the comparatively soft underlying sandstone and shale from the agents of erosion.

ALLUVIUM.

Alluvium of excellent fertility is present in belts of varying width along all perennial streams in this region. Along Bighorn River alluvium constitutes the present flood plain, which varies from one-third of a mile to about 2 miles in width, the widest part being in the northern part of T. 51 N., R. 93 W. The maximum thickness of the alluvium is unknown but probably reaches 50 feet in the vicinity of Basin.

STRUCTURE.

GENERAL FEATURES.

Structurally the Bighorn Basin is a great downfold with its longer axis trending northwest. It is limited in general on the east, south, and west by the enormous upfolds of the Bighorn, Owl Creek, and Absaroka mountains, respectively. The flanks of the syncline or edges of the basin are corrugated by small folds trending very regularly northwest. Some of these minor anticlines contain oil and gas in commercial quantities.

The structural features of greatest importance to the oil operator in the field here described are the Torchlight dome and the Lamb anticline. Both of these are on the same upfold on which the Peay Hill anticline is situated. The Peay Hill anticline is also of importance near the mouth of Greybull River as a reservoir of oil and gas, but a complete description of it will be reserved until further field work is done. At the south side of the area shown on Plate XVII there is an anticline which extends several miles southeast of No Wood Creek. In the southeastern part of this area, crossing sec. 35, T. 51 N., R. 92 W., there is a small northwestward-trending anticline regarding which the writer has little definite information. The rocks west of Bighorn River have a general westward dip toward the middle of the basin, ranging from 21° on the lowest beds exposed near Basin to about 50° on some of the higher beds a short distance west of the town.

The structure contours shown on Plate XVIII (p. 188) are drawn on the upper surface of the Greybull sand (top of the Cloverly formation). They are lines connecting points of equal altitude on this surface, and thus they show the deformation that the sand as well as all the other rocks have suffered in the wrinkling that has taken place in the bottom and on the rim of the great synclinal fold.

The value of structure contours lies in the fact that they show clearly the shape of the deformed rocks and, as oil and gas tend to collect in the anticlines, they show the areas most favorable for the location of wells. By their use the prospector may also determine roughly the distance which the drill must go in order to reach any particular sand at any particular place. As the contours are drawn on the upper surface of the Greybull sand, it is easy to find the depth of that sand below the surface by subtracting the altitude of the sand at any point, as shown by the structure contours, from the surface altitude. For example, the depth of the Greybull sand at well No. 12, on the eastern edge of the Torchlight dome, in the west-central part of sec. 19, T. 51 N., R. 92 W., may be found by subtracting 2,850 feet (the well is situated halfway between the 2,800-foot and 2,900-foot contours), the altitude of the sand, from 4,203 feet, the altitude of the well mouth. The remainder, 1,353 feet, is the approximate thickness of strata between the surface and the top of the Greybull sand, or, in other words, the depth to the sand. In this manner the depth to the Greybull sand at any point in the field may be determined.

To determine the depths of any other sand it is generally more convenient first to calculate the depth of the Greybull and then to subtract from the result the distance from the top of the Greybull to the top of the other sand. Thus having found the depth of the Greybull in well No. 12 as 1,353 feet, the depth of the Kimball sand would be 1,353 – 830, or 523 feet, and that of the Muddy sand would be 1,353 – 275, or 1,078 feet. The operation outlined is based on the assumption that the sands are parallel to one another. So far as can be judged from the data at hand this seems a reasonable assumption, but it may be found that the sands are not parallel and so the depth of a sand calculated by this method may not be correct. If it is found on further drilling that such calculations are not accurate, the variations should be noted to see if they are all in the same direction—that is, all too great or too small—and then allowance should be made in future work for the increased or lessened interval.[1]

TORCHLIGHT DOME.

The Torchlight dome is an elongated dome with its axis trending northwest and is situated mainly in secs. 24 and 25, T. 51 N., R. 93 W., and secs. 19 and 30, T. 51 N., R. 92 W. At the north it is closely related structurally to the Lamb anticline, the axis of which at its nearest point is within 1½ miles of the axis of the Torchlight dome. The length of the Torchlight dome is about 3 miles and the width about 2 miles. The maximum diameter of the outcrop of the Torchlight sandstone in this structure is about 1 mile. The strata dip more steeply on the southwest side of the dome than on the northeast side, as is shown by dips recorded at different places and shown on Plate XVIII. The southwestward dips vary from a fraction of 1° near the center of sec. 24 to about 22° in the SW. ¼ SW. ¼ sec. 25, T. 51 N., R. 93 W. In passing from the center of the dome to the west, southwest, and south, the dip of the strata is gentle at first, then gradually increases to about 20° at a distance of about 1 mile from the center. Beyond this point the beds have a nearly constant dip of 20° to 25° to the edge of the area represented on Plate XVIII. To the east and southeast the maximum dip observed is 9° near the point where the strike of the beds swings abruptly from N. 87° E. to N. 17° W. Along the northeast flank of the dome the greatest dip is 8°, in the NE. ¼ NE. ¼ sec. 24, T. 51 N., R. 93 W.

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[1] Many readers will doubtless compare the structure contours shown on Plate XVIII with those given in Bulletin 10 of the Wyoming Geological Survey and will note that there is a distinct difference. Part of this difference can be explained by the fact that in Bulletin 10 the contours are drawn on the top of the Peay sand, which is about 1,050 feet above the Greybull sand, the datum surface used by the writer. The most striking difference, however, is in the shape of the structures portrayed on the two maps. This can be explained only by the fact that the present writer had much more complete data than were available to Mr. Hintze, and hence it is believed that the structure of the folds in this field is much more accurately represented on Plate XVIII than it is in Bulletin 10 of the Wyoming Survey.

In Bulletin 10 it is suggested that the southeast end of the Torchlight dome is not accurately represented, and this is borne out fully by data in the writer's possession. In several places on the map in Bulletin 10 the structure contours are as much as 300 feet too low, as shown by the data contained in that report. This error is extremely important, as it gives the impression that any given sand in those particular areas lies 300 feet deeper than it actually does.

LAMB ANTICLINE.

The Lamb anticline is a larger structural feature than the Torchlight dome, being about 5 miles long and 4 miles wide. Generally the dips are light; a maximum of 10° was noted on the northeast flank, in the SE. ¼ SW. ¼ sec. 7, T. 51 N., R. 92 W. The beds on the southwest flank within 1 mile of the axis have their greatest inclination (5°) in the SW. ¼ SE. ¼ sec. 11, T. 51 N., R. 93 W. Over a large part of the area represented by this anticline good exposures are so scarce that it is difficult to determine the attitude of the beds.

The syncline separating the Torchlight dome and Lamb anticline is narrow and comparatively shallow, as shown by the structure contours drawn on the Greybull sand.

OTHER FOLDS.

The Peay Hill anticline (shown on Pl. XVII), near the mouth of Greybull River, has yielded considerable oil and gas, but it has not been examined by the United States Geological Survey and its approximate position only is given.

Four miles south of the Torchlight dome is the end of a northwestward-trending anticline, which, according to reports, attains considerable proportions south of No Wood Creek. The lowest rocks exposed in this fold north of the creek are not older than Montana, but it is believed that south of No Wood Creek beds of Colorado age are exposed at the surface, and it is reported that some drilling has been done there. A maximum dip of 14° was measured on the northeast flank of this anticline near the center of sec. 21, T. 50 N., R. 92 W. On the southwest flank the greatest observed dip (21° SW.) is in the southern part of sec. 13, T. 50 N., R. 93 W. The axis of the syncline, which lies parallel with and northeast of this anticline, is comparatively close to the axis of the anticline on the north side of No Wood Creek, varying from less than a quarter of a mile near the center of sec. 12, T. 51 N., R. 93 W., to slightly more than 1¼ miles where the axes cross No Wood Creek.

In the southeastern part of T. 51 N., R. 92 W., there is a gentle anticline which trends nearly north and south. Little detailed information regarding this fold was collected, so that its extent and magnitude are not known.

OIL AND GAS.

OCCURRENCE.

WELLS AND PRODUCING SANDS.

In all, fifty-two wells have been drilled in this field up to October 10, 1915. The records of all these wells except three (Nos. 12, 17, and 30 [1]) are at hand and have been studied with care, but only a few can be published in detail, as they have been furnished by the owners on the condition that they be treated as confidential information. However, certain deductions drawn from their study are given at different places in this paper.

The Kimball sand, in the Mowry shale, is the largest producer of oil, and the Peay sand, in the Frontier formation, is the most important reservoir for gas in the Basin field. The other sands are of little or no importance as oil or gas reservoirs. The Torchlight sand yields oil in one well, oil and gas in one, and water in two, and in fifteen other wells it is dry. A lenticular sand between the Peay and Torchlight sands furnishes a little oil in one well, gas in five wells, and oil and gas in one and is dry in one hole. The Peay sand contains oil in one well, gas in six, oil and gas in four, and water (fresh or sulphurous) in forty-one, and in four holes it is dry. The Kimball sand yields oil in twenty-nine wells, oil and gas in two, and water in four, and in seven it is dry. The Octh Louie sand carries a little oil in twenty-one wells, and in the remaining five it is barren of oil, gas, and water. The Muddy sand contains gas in three wells and water in two, and in two it is dry. The Greybull sand carries water in five holes and in one it is dry.

OIL IN THE TORCHLIGHT DOME.

In the Torchlight dome most of the oil is obtained from the Kimball sand, but oil is found also in commercial quantities throughout the Mowry shale and in the Peay sand and traces occur in some of the other sands. Seven holes penetrated the Torchlight sand, which is barren in five of them, oil bearing in one, and oil and gas bearing in one. The stray sand between the Peay and Torchlight sands was recognized in only one well, where it shows oil. The Peay sand was drilled through in thirty-four wells; one well showed gas alone, three oil and gas, thirty water, and four were absolutely dry.[2] The Kim-

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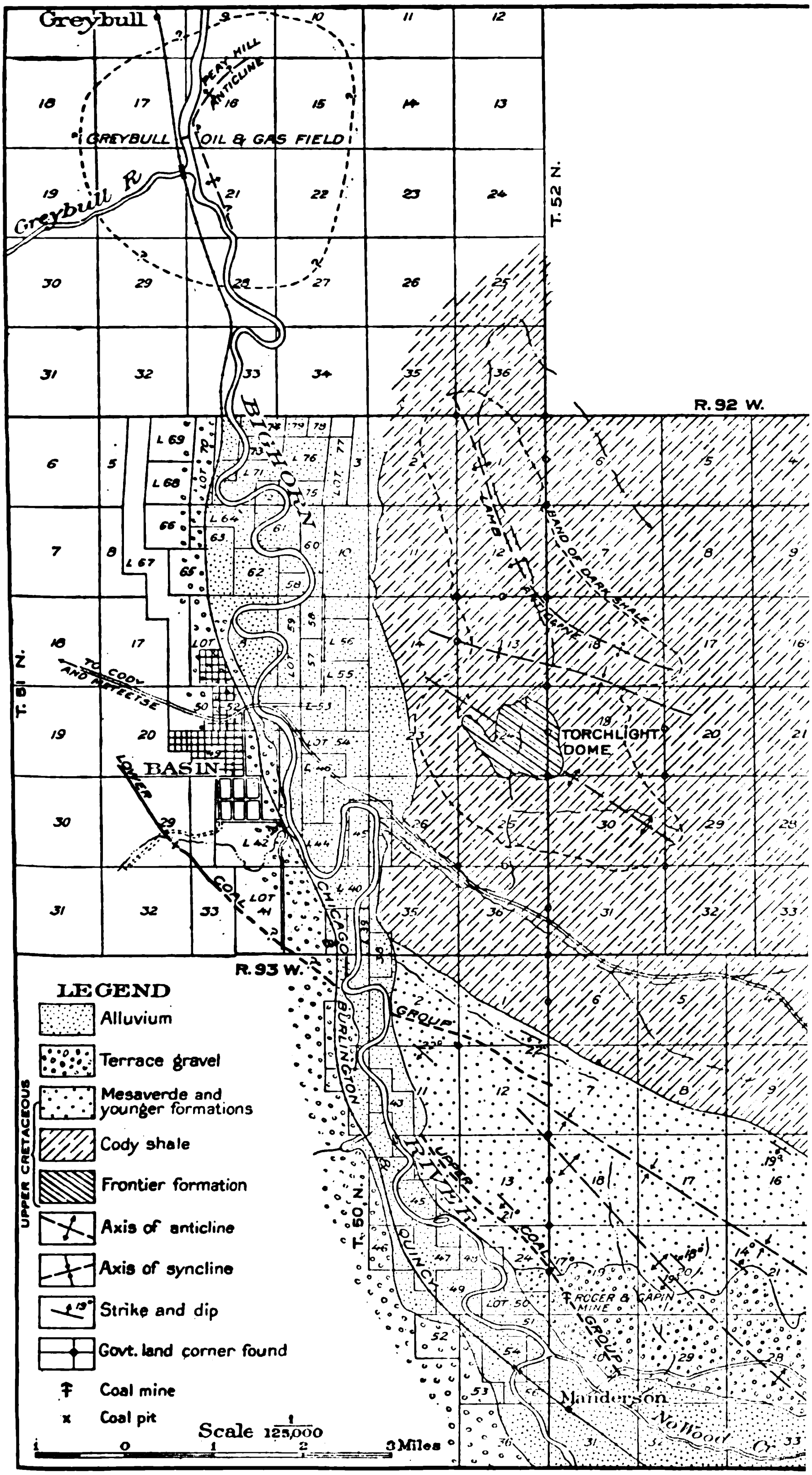
[1] Numbers of wells refer to corresponding numbers on Plate XVIII (p. 188).

[2] In many wells water occurs in a different part of the same sand that carries oil or gas; hence in these summaries the total of wells showing oil, gas, and water may not be the same as the number of wells drilled.



GEOLOGIC MAP OF THE BASIN OIL FIELD AND ADJACENT AREAS, WYOMING.

ball sand was encountered in thirty-two wells. In twenty-eight it produced oil, in two oil and gas, and in three water. In twenty-three wells the Octh Louie sand (or stray sand below the Kimball) was recognized. It contains some oil in all the wells, but not as much as the Kimball sand. The Muddy sand was encountered in three wells, in two of which it furnished a little gas and in one it was dry. Three wells in the Torchlight dome penetrate the Greybull sand, which in all three carries fresh water.

The productive area of the Torchlight dome, so far as development has gone, is limited by one dry hole (No. 7) on the north, another (No. 13) on the south, and one (the Cleveland-Wyoming well) in the NW. ¼ NE. ¼ sec. 22, T. 51 N., R. 93 W., about 1½ miles west of the westernmost producing wells in this dome. Well 14, which is about as far from the center of the dome as well 13, is reported to have encountered oil in the highest or Torchlight sand. The productive area has not been outlined even in a general way on the east and not closely on the west. It is believed, however, that future drilling will prove that the productive area is limited on the north by a line midway between the 2,700 and 2,800 foot structure contours and on the east, south, and west by the 2,500 or 2,600 foot contour. This latter boundary is arbitrary and is drawn halfway between the contours of known productive and nonproductive territory on the east, south, and west. Oil will probably be found lower on the west slope of the dome than on the east slope, to judge from the distribution of oil in other structural features in the Bighorn Basin. The fact that oil is reported from the Torchlight sand in well 14 and a show of oil and gas in well 7 suggests that this sand carries a little oil in the Torchlight dome.

These assumptions are based on the following facts: On the north side of the dome well 7, which yields neither oil nor gas but carries water in the Kimball sand, is just north of the 2,600-foot contour, and well 5, which encountered oil in the Kimball sand and water below it, is just north of the 2,800-foot contour. The line separating oil-bearing from non oil-bearing territory must be between these two structure contours. Hence, it is assumed that the limit of the oil-bearing territory is approximately midway between the 2,600 and 2,800 foot structure contours or on the 2,700-foot contour. Drilling may prove, however, that the productive area of the Torchlight dome is continuous with the productive area of the Lamb anticline in secs. 13 and 14, T. 51 N., R. 93 W. The presence of water in the Kimball sand in wells 7, 13, and 25 suggests strongly that water occurs in the Kimball sand around these folds at the altitude of this sand in these wells and probably is in part the cause of the segregation of the oil in the Kimball sand at the crest of the Torchlight dome. The fact that the Kimball sand does not contain oil in wells 7 and 13 is presumptive evidence that the area in which oil will be found in this sand in commercial quantities is much smaller than the area in which traces of oil are found in the overlying Torchlight sand. The Greybull sand is believed to be barren of oil and gas in the Torchlight dome. W. L. Walker, consulting geologist for the Valentine interests in this field, makes the following statement regarding this sand in the Hiatus well (No. 10):

> In the Hiatus well, which is located about 200 feet southeast of the southeast corner of sec. 24, T, 51 N., R. 93 W., the Greybull sand was found to contain water. The water is under a hydraulic head of several hundred feet and was present in such quantity that the hole could not be cleared by bailing. No trace of oil was noted. At this point in the Torchlight dome, but little more than a half mile from the summit of the fold, the Greybull sand is not oil bearing. I have had no personal connection with any operations which have tested this sand at any point nearer the center of the structure. While the Hiatus well does little more than indicate that the possible oil-bearing area of this sand is of less extent than the known productive area of the Kimball sand, certain other conditions in the district appear to give basis for doubting the productiveness of the Greybull sand generally in the Torchlight dome.

OIL IN THE LAMB ANTICLINE.

The Torchlight sand was penetrated in 10 wells in the Lamb anticline, and in all of these except No. 28, which yields water, the sand is dry. A stray sand between the Peay and Torchlight sands was encountered in seven wells. In five of these gas in varying amounts was struck in this sand; in one (No. 29), the partial log of which is given on page 160, a little oil and gas are present; and in one the sand is dry. Eleven wells cut the Peay sand. One of these (No. 20) yields oil; five gas; one (No. 28) a trace of oil and gas; and nine either fresh or salt water. The Kimball sand was encountered in eight wells. One of these yields oil and one water, and the others are dry. The Octh Louie sand was cut by the drill in four wells and in each is dry. The Muddy sand is known to have been encountered in two wells. In one of these (No. 28) the sand is dry and in the other (No. 18) it carries fresh water. Only one well (No. 28) in the Lamb anticline penetrated the Greybull sand; it is reported to have found water only.

The productive area of the Lamb anticline is limited to a narrow belt one-fourth to one-half mile in width on the northeast side of the axis and another from one-fourth to 1 mile in width on the southwest side. At the southeast end it is limited by a line northwest of well 15, which reached the Octh Louie sand. In secs. 2 and 11, T. 51 N., R. 93 W., the western limit of productive territory probably follows the 2,500-foot contour, except in the NE. ¼ sec. 2, where the line swings to the west around well 20, which produces oil. At the southwest side of the anticline the line is probably not more than one-third of a mile south of the south boundary of secs. 11 and 12, T. 51 N., R. 93 W. The position of the line separating the productive from the nonproductive territory in this anticline is based on the position of the water table in the Peay sand, which is the principal oil-bearing sand in this anticline. It is significant that in well 21, which is the nearest well of economic importance to the Torchlight dome, the oil occurs in the Kimball sand, which is the most productive sand in the dome. This fact suggests that there is a connection between the two productive areas in the Kimball sand.

As indicated on the map of the Basin field (Pl. XVIII) there are two dry holes (Nos. 24 and 26) outside of the Torchlight dome and Lamb anticline. In each of these wells the Torchlight sand is dry, the Peay sand carries water, and the Kimball sand is dry. The Muddy sand yields a little gas in one well and in the other it carries water. In one well (No. 24) the Greybull sand is dry and in the other (No. 26) it contains water.

The oil and gas in this field occur on the highest parts of the upfolds, thus supporting the anticlinal theory. In different parts of both folds, as stated above, at distances varying from half a mile to 1¾ miles from the axes shown on the map, the wells do not encounter oil or gas.

The productive sands in the Basin field contain considerable water adjacent to the oil and gas bearing portions. Some wells show water in the same sand in which oil and gas occur, but in practically all the wells the water is not present at the same horizon as the gas and oil. This is true for the Peay sand in both the Lamb anticline and the Torchlight dome. In only one well (No. 5) in the Basin field does water occur with oil or gas in the Kimball sand. Water in the various oil and gas bearing sands doubtless has played an important part in causing the oil and gas to collect in the higher parts of the structure.

Gas in the Lamb anticline comes from the Peay sand only and at the present time is used by the towns of Basin and Greybull. These places have the distinction of being the only towns in Wyoming that use natural gas.

CHARACTER OF THE OIL.

The oil from the Torchlight dome is higher in grade and contains much more gasoline and kerosene than that from the Lamb anticline, as is indicated by the analyses given below. It has a dark-green color in reflected light and a deep wine color in transmitted light.

A sample of oil which is believed to be a fair representative of the oil of this dome was collected from Jackson No. 3 well (No. 27), in the NE. ¼ SW. ¼ sec. 24, T. 51 N., R. 93 W., from the Kimball sand. Some of the gasoline may have escaped before reaching the office, as the container came unsealed. The following analysis made in the laboratory of the Bureau of Mines shows the character of this oil:

Analysis of crude petroleum from Jackson No. 3 well (No. 27), in the NE. ¼ SW. ¼, sec. 24, T. 51 N., R. 93 W.

[Began to boil at 75° C.]

	Per cent.	
Gasoline:		
To 100° C	10	
100° to 125°	7	
125° to 150°	9	
		26
Kerosene:		
150° to 175°	7	
175° to 200°	5½	
200° to 225°	5	
225° to 250°	7½	
250° to 275°	4½	
275° to 300°	5	
		34½
Residuum		39½
		100

Specific gravities at 60° F.:

Crude oil	0. 8260 (39. 5° Baumé).
Gasoline	. 7444 (58. 0° Baumé).
Kerosene	. 8104 (42. 7° Baumé).
Residuum	. 8935 (26. 7° Baumé).

The oil from the Lamb anticline contains no gasoline and much less kerosene than the oil from the Torchlight dome. The residuum is excellently suited for lubricating oil. A sample of oil from this anticline was collected from Wilson No. 1 well (No. 20), in the NW. ¼ NW. ¼ sec. 1, T. 51 N., R. 93 W., from the lower part of the Peay sand. The oil has a very dark green color in reflected light and does not transmit light. Thin films of the oil are yellowish brown in color. The oil from which the sample was taken came from the well in June, 1914, and was stored in an air-tight barrel until October of the same year, when it was sent to the laboratory for analysis. An analysis of this sample made in the laboratory of the Bureau of Mines is as follows:

Analysis of crude petroleum from Wilson No. 1 well (No. 20), in the NW. ¼ NW. ¼ sec. 1, T. 51 N., R. 93 W.

[Began to boil at 180° C.]

	Per cent.	
Kerosene:		
To 200° C	½	
200° to 225°	1½	
225° to 250°	3	
250° to 275°	8½	
275° to 300°	9	
		22½
Residuum		77½
		100

Specific gravities at 60° F.:

Crude oil	0. 8889 (27. 5° Baumé).
Kerosene	. 8476 (35. 2° Baumé).
Residuum	. 9038 (24. 9° Baumé).

Another sample of oil for analysis was collected from Kimball No. 3 well (No. 9 on Pl. XVIII). This oil comes principally from the Kimball sand, near the top of the Mowry shale. The sample arrived at the laboratory in excellent condition, the bottle being well sealed, and hence at the time of analysis probably was little changed from its condition at the time it was collected. The analysis, which is given below, was made in the laboratory of the Bureau of Mines:

Analysis of crude petroleum from Kimball No. 3 well (No. 9 on Pl. XVIII), in lot 13, sec. 19, T. 51 N., R. 92 W.

[Began to boil at 34° C.]

	Per cent.	
Gasoline:		
To 50° C.	2½	
50° to 75°	4½	
75° to 100°	6	
100° to 125°	10	
125° to 150°	7½	
		30½
Kerosene:		
150° to 175°	6	
175° to 200°	5½	
200° to 225°	5½	
225° to 250°	6	
250° to 275°	5½	
275° to 300°	9½	
		38
Residuum		31½
		100

Specific gravities at 60° F.:

Crude oil	0.7955	(45.98° Baumé).
Gasoline	.7216	(64.0° Baumé).
Kerosene	.8102	(42.8° Baumé).
Residuum	.8425	(36.2° Baumé).

Oil from the Greybull field (Peay Hill anticline) is reported to be reddish green in color and to have a gravity of about 47° Baumé. It "freezes" on cooling into a stiff yellowish mass, which is said to be almost pure gasoline with a low flash point.

The subjoined commercial analysis was furnished by Homer T. Lamb, manager of the Greybull Oil Co. and the Bighorn Oil & Gas Co., of Greybull, Wyo. This analysis shows the various commercial products that are obtained in refining oil from the Torchlight and Greybull domes:

Commercial analysis of oil from Torchlight and Greybull domes, Wyoming.

	Per cent.
Crude naphtha	18.2
Superfine white stock	21.2
Water-white stock distillate	21.9
300 stock	5.0
Wax stock	19.1
Cylinder stock	8.0
Loss	6.6
	100.0

The "crude naphtha" (18.2 per cent) corresponds to the gasoline in the analysis made by the Bureau of Mines. The amount of gasoline determined by the Bureau of Mines analysis, however, is about 8 per cent higher than that shown for "crude naphtha" in the analysis given above. The total amount of kerosene in the bureau analysis is about 8 per cent less than the kerosene percentage in Mr. Lamb's analysis. The total of kerosene and gasoline in each analysis, however, is approximately the same, the bureau analysis showing 60.5 per cent and Mr. Lamb's analysis 61.3. It is possible that the "superfine white stock" contains some of the gasoline separated by the Bureau of Mines and that the "crude naphtha" does not include all the gasoline content.

Oil from the Bonanza Spring, referred to in this report, was analyzed by E. E. Slosson, of the University of Wyoming, and the essential part of the distillation of the product is given below:

Distillation of Bonanza petroleum.[a]

[Specific gravity of crude petroleum, 0.850 or 34.6° Baumé.]

Boiling point.	Gravity of distillate.	
	Specific.	Baumé.
		Degrees.
60° to 157° C.	0.762	53.5
157° to 200° C.	.792	46.5
200° to 237° C.	.822	40.3
237° to 273° C.	.843	36.1
273° to 297° C.	.853	34.1

[a] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, p. 59, 1906.

This table shows that the oil begins to boil at 60° C. The part distilling between 60° C. and 157° C. was practically all gasoline, which has a specific gravity slightly lower than the gasoline from Jackson No. 3 well, in the Torchlight dome. All material distilling between 157° C. and 297° C. is kerosene, the specific gravity of which varies from 0.792 to 0.853, or from 46.5° to 34.1° Baumé. The specific gravity of the kerosene from Jackson No. 3 well is 0.8104 (42.7° Baumé). These comparisons show that the oil from the Bonanza Spring is probably similar to that from the Torchlight dome.

CHARACTER OF THE GAS.

All wells that yield oil in the Torchlight dome produce also a little gas. In fact some of the wells furnish enough gas to cause the oil to flow. The principal gas wells in the area shown on Plate XVIII are located on or near the axis of the Lamb anticline, in the E. ½ sec. 12, T. 51 N., R. 93 W., and the extreme western part of sec. 7, T. 51 N., R. 92 W. Gas from these wells is from the Peay sand and is without color but has a strong odor. Lane No. 1 well, the original large gas well (No. 23), produces more gas than any of the other wells drilled in the Torchlight dome and Lamb anticline. A sample of gas from this well was collected for analysis by displacement of air. The results of this analysis are given below:

Analysis of natural gas from Lane No. 1 well (No. 23), in the SE. ¼ SE. ¼ sec. 12, T. 51 N., R. 93 W.[1]

[Laboratory No. 5722; G. A. Burrell, analyst.]

Specific gravity (air free), 0.59.

Carbon dioxide (CO_2)	0.4
Oxygen (O_2)	.0
Methane (CH_4)	93.5
Ethane (C_2H_6)	3.5
Nitrogen (N_2)	2.6
	100.0

The heating value of this gas at 0° C. and 760 millimeters pressure (calculated) is 1,061 British thermal units.

Two samples of gas from the Greybull field were collected by W. R. Calvert[2] in 1912. Their analyses are given below, together with Calvert's comments.

Analysis of natural gas from Greybull, Wyo.

[G. A. Burrell, analyst.]

	3224	3222
Density (air=1)	0.64	0.77
Carbon dioxide (CO_2)	0.20	0.00
Oxygen (O_2)	.00	.00
Methane (CH_4)	81.70	51.55
Ethane (C_2H_6)	17.35	47.20
Nitrogen (N_2)	.75	1.25
	100.00	100.00
Claroline absorption ... per cent	.26	22.60
Gross heating value, at 0° C. and 760 millimeters pressure ... British thermal units	1,192	1,427

Sample No. 3224 is from the Island No. 1 well, one of the eight wells that produce gas commercially. The initial production of this well was 750,000 cubic feet at a rock pressure of 120 pounds. The volume was not ascertained at the date of the writer's visit, but the pressure has decreased to 30 pounds.

Sample No. 3222 is of casing-head gas from a nonproducing well in which some oil was found, the object being to ascertain the difference, if any, between this "wet" gas and that from the "dry" gas wells. As shown by the analyses the gases have a different composition. The composition of the gas represented by sample No. 3224 is practically identical with that of the natural gas supplied to Pittsburgh, Pa., according to analyses made by Burrell.

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[1] This analysis is slightly in error because a small amount of whisky may have been taken up by the sample from the cork of the bottle in which the gas was contained.

[2] Calvert, W. R., A preliminary report on the utilization of petroleum and natural gas in Wyoming: U. S. Bureau of Mines Tech. Paper 57, p. 13, 1913.

As the gas from Lane No. 1 well (laboratory No. 5722) is from a sand that yields an oil much lower in gasoline than the sand from which samples Nos. 3224 and 3222 were taken, it is reasonable to expect that the last two samples should be higher in ethane, a prominent constituent of gasoline, than the first.

PRODUCTION.

It is estimated that the total production of oil from the Torchlight dome is probably about 800 barrels daily, or nearly 300,000 barrels a year, on a basis of twenty-seven producing wells. Shooting the wells and additional drilling will probably increase this amount considerably.

The wells drilled in the Lamb anticline at the time the field was examined (October, 1914) were not producing, as pipe-line connections had not been made. Although the oil is of a lower grade than that from the Torchlight dome, there is no reason to believe that the yield per well will not be approximately as great.

Only three wells (Nos. 18, 22, and 23) in the Lamb anticline are producing gas in commercial quantities. These wells are reported to yield sufficient gas to supply the towns of Basin and Greybull. It is estimated that these three wells when first drilled each yielded approximately 5,000,000 cubic feet of gas daily, or 1,825,000,000 cubic feet a year. Each well had a rock pressure of 147 pounds to the square inch. The gas is furnished to customers in Basin and Greybull at 40 cents a thousand cubic feet for eight months of the year and 35 cents a thousand for the remaining four months.

WELLS DRILLED.

The greatest number of wells drilled in the Torchlight dome and Lamb anticline were begun and completed in 1913, 1914, and 1915. Information regarding the wells is given in the following table:

Wells drilled in the Basin oil field, Wyoming.

NOTE.—Between November, 1914, and October 10, 1915, 22 wells were drilled in the Torchlight dome. Their location is not shown on Plate XVIII, but some notes on them, with logs of two of the wells, are given in the text below.

No. on Pl. XVIII.	Name.	Company.	Results.	Depth in feet.
1	Original gas well	Torchlight Drilling & Mining Association.	A little gas	106
2	No. 2	do.	Gas and a little oil.	222
3	Torchlight No. 1	Valentine interests	Oil	(a)
4	Torchlight No. 2	do.	do.	(a)
5	Jackson No. 2	Greybull Oil Co.	do.	(b)
6	Jackson No. 1	do.	do.	(b)
7	Champion No. 1	Champion Oil Co.	Show of oil and gas	? 816
8	Kimball No. 1	Greybull Oil Co.	Oil	(b)
9	Kimball No. 3	do.	do.	(b)
10	Hiatus No. 1	Valentine interests	Oil and gas	(a)
11	Kimball No. 2	Greybull Oil Co.	Oil	(b)
12	Cleveland-Wyoming No. 1.	Cleveland-Wyoming Oil Co.	do.	(?)
13	Schaeffer	Greybull Oil Co.	Water	1,090
14	Champion No. 2	Champion Oil Co.	Oil reported	210
15	Durham No. 1	Greybull Oil Co.	Water	1,088
16	Cushing No. 1	do.	Gas	(c)
17	Harvey No. 1	do.	Dry	(?)
18	Columbia No. 1	do.	Gas and fresh water.	(c)
19	Griggs No. 1	do.	Dry	(c)
20	Wilson No. 1	do.	Oil and gas	(c)
21	Lane No. 2	do.	Oil	(c)
22	Jennings No. 1	do.	Gas	(c)
23	Lane No. 1	do.	do.	(c)
24	Ruth	do.	Water and a little gas.	2,100
25	Armstrong No. 1	do.	Fresh water	965
26		do.	Water	1,800±
27	Jackson No. 3	do.	Oil, gas, and fresh water.	(b)
28	Padmore	Valentine interests	A little water	(a)
29	Union Gas & Oil Co.'s well.	Union Gas & Oil Co.	Trace of oil and gas	1,100±
30	Cleveland-Wyoming well No. 2.	Cleveland-Wyoming Oil Co.	Oil and gas	400+

[a] The exact depths of producing wells are confidential and are withheld at the request of the different oil companies.

[b] Most of these wells vary in depth from 450 to 700 feet, according to their position on the dome.

[c] Most of these wells vary in depth from 450 to 900 feet.

Complete information regarding all the wells listed above was not obtained. If "oil" or "gas" is not shown in the "Results" column, the well is considered a dry hole.

Development has been very active on the Torchlight dome since the field was examined in October, 1914. During the following 12 months 22 additional wells have been drilled, mainly in the interior of the dome. Twenty of these wells are on the Kimball and Jackson claims of the Greybull Oil Co. One well was drilled by the Valentine interests on the Philip Minor claims, in the NE. ¼ SE. ¼ sec. 24, T. 51 N., R. 93 W., about 300 feet west of Kimball well No. 3 (No. 9 on Pl. XVIII), and one by the Cleveland-Wyoming Oil Co. on the Tillard claim, in the NW. ¼ NE. ¼ sec. 22, about 1¼ miles west of any other wells on this dome.

All these wells except the Cleveland-Wyoming well have encountered oil in commercial quantities in the Kimball and Octh Louie sands of the Mowry shale, at depths ranging from 400 to 600 feet. The Cleveland-Wyoming well was not drilled deep enough to penetrate the Mowry shale. A trace of oil is said to have been encountered this well.

Ten of the wells drilled by the Greybull Oil Co. are on the Jack claim, which includes the E. ½ W. ½ sec. 24, and are known as Jack wells Nos. 4 to 13, inclusive. Jackson No. 4 is 350 feet north Jackson No. 1 (No. 6 on Pl. XVIII); Jackson No. 5 is 350 feet sou of Jackson No. 3 (No. 27, Pl. XVIII); Jackson No. 6 is 350 feet sou of Jackson No. 5; Jackson No. 7 is 350 feet north of Jackson No. Jackson No. 8 (No. 33, Pl. XVIII) is 350 feet north of Jacks No. 7; Jackson No. 9 is 350 feet north of Jackson No. 8. The log well No. 8 follows:

Partial log of Jackson well No. 8, in the SE. ¼ NW. ¼ sec. 24, T. 51 N., R. 93 W.

	Depth (feet).
Top of Peay sand (yields sulphur water)	265
Top of Kimball sand (yields oil)	475
Top of Octh Louie sand (yields oil)	548
Bottom of hole	606

Well No. 8 was begun June 26 and completed July 6, 1915. A Star rig was used in drilling this well, as in all wells drilled by the Greybull Oil Co. in this field. The altitude of the mouth of the well is approximately 4,170 feet above sea level. Homer T. Lamb, manager of this company, states that the strata between the top of the Kimball sand and the base of the Octh Louie sand, or practically all of the Mowry shale, carry some oil.

Jackson well No. 10 is 350 feet south of Jackson No. 6; Jackson No. 11 is 350 feet south of Jackson No. 10; Jackson No. 12 is in the SE. ¼ NW. ¼ sec. 24, about 150 feet from the west line and 500 feet from the south line; Jackson No. 13 is 350 feet north of Jackson No. 12.

Ten wells have been drilled by the Greybull Oil Co. on the Kimball claim, which includes the west range of forties in sec. 19, T. 51 N., R. 92 W., and are known as Kimball wells Nos. 4 to 13, inclusive. These wells reach the oil-bearing rocks at depths similar to those on the Jackson claim, as is shown by the log of Kimball well No. 7 (No. 49, Pl. XVIII) given below:

Log of Kimball well No. 7, in lot 14, sec. 19, T. 51 N., R. 92 W.

	Depth (feet).
Top of Peay sand (yields sulphur water)	287
Top of Kimball sand (yields oil)	500
Top of Octh Louie sand (yields oil)	585
Bottom of hole	631

This well was commenced February 4 and completed February 15, 1915. The altitude of its mouth is about 4,148 feet.

The new wells on the Kimball claim are situated as follows: Kimball Nos. 4, 5, 6, and 7 are at 350-foot intervals in order south from

Kimball well No. 3 (No. 9, Pl. XVIII); Kimball Nos. 8, 9, 10, 11, and 12 are at 350-foot intervals in order north from Kimball No. 1 (No. 8, Pl. XVIII); Kimball No. 13 is 350 feet east of Kimball No. 7.

The Cleveland-Wyoming Oil Co.'s well in the NW. ¼ NE. ¼ sec. 22, T. 51 N., R. 93 W., was commenced March 15 and finished April 10, 1915. It is about 900 feet deep and at the bottom encountered a sand that carried a little water. This sand is probably a thin bed in the lower part of the Cody shale, about 100 feet above the top of the Torchlight sand. About six weeks after the drilling operations were completed the well had filled with water. A scum of oil was on the water and about the casing where the water had overflowed. Whether the oil came up with the water or was put there by someone interested in creating an oil excitement is an unsettled question.

Information collected in the summer of 1915, too late to be incorporated in Plate XVIII, indicates that the small dome at the end of the Lamb anticline is not so well defined nor so sharply separated from the main fold as is shown on the map. The 2,400-foot contour, instead of closing in secs. 35 and 36, T. 52 N., R. 93 W., swings to the north and east through sec. 36 of the same township and secs. 31 and 30, T. 52 N., R. 92 W., keeping about half a mile to the east and north of the Ruth well (No. 24). From this point it swings to the west and southwest, joining the 2,400-foot contour, as represented in Plate XVIII on the west side of the main anticline, near the southwest corner of sec. 2, T. 51 N., R. 93 W. The depression between the Lamb anticline and the next dome to the north is so slight that the 2,300 and 2,200 foot contours do not connect around the north end of the anticline, as is suggested by that part shown in Plate XVIII.

The Griggs well No. 1 (No. 19, Pl. XVIII), in the S. ½ sec. 1, T. 51 N., R. 93 W., is shown on the map as an "oil and gas well." The yield of oil and gas in this well is so slight, according to Homer T. Lamb, that it should be considered a dry hole.

CONCLUSIONS.

As the Torchlight dome and Lamb anticline are comparatively small structural features, the amount of oil and gas that they can produce is necessarily limited. It is believed that the outlines of producing territory in these folds can not be determined by the wells now drilled, but will be pushed outward in both areas by further drilling, that the initial yield will be much enhanced by careful shooting of the wells, and that the life of the field will be prolonged by preventing the escape of gas. The production will be greatly increased by more thorough drilling inside of the limits of the productive area already approximately determined. As the areas in which gas has been found in commercial quantities are rather small, and the areas in which oil has been found are considerably larger, it seems safe to predict that further drilling within limited areas wi yield more oil than gas and that the field will be preeminently a oil field.

The lowest sand containing oil or gas in commercial quantities i these structures is the Kimball, or top sandstone of the Mowry shale Deeper drilling in the Lamb anticline may possibly prove that th Greybull sand of the Cloverly formation contains oil or gas, but thi is doubtful. It is also possible, but hardly probable, that the more prominent sandstone beds in the Morrison formation, which underlies the Cloverly, may prove to be of importance as producers of oil and gas in both the Torchlight dome and the Lamb anticline, as the oil known to be present in places in the late Carboniferous limestone may have ascended to and saturated these porous beds.

The operation of a refinery in this general region near the railroad undoubtedly would be of economic importance to the companies producing oil in this part of the Bighorn Basin. Such a plant is now being constructed at Greybull, about 5 miles northwest of the Lamb anticline, and probably will be in operation before this report is published.

GEOLOGY AND OIL PROSPECTS OF CUYAMA VALLEY, CALIFORNIA.

By Walter A. English.

INTRODUCTION.

The Cuyama Valley (shown in fig. 12), lying between the Santa Maria oil fields on the coast and the Sunset-Midway field in the San Joaquin Valley, has attracted the attention of oil men for many years; and were it not that the region lies far from the railroad and that the price of oil during the last few years has been so low as to render wildcat drilling somewhat unattractive, the valley would probably have been tested by a considerable number of wells before this time. The region not only lies between two of the richest oil fields of the State, but much of it is underlain by rock formations similar to those in which oil occurs in the productive fields, and in places oil seeps out at the surface. In order to determine whether or not oil might be expected to occur in commercial quantity in this region, and if so to point out the areas that offer the greatest promise, the writer undertook an examination during the fall of 1914.

On the basis of the geologic evidence in hand the chance for the development of a commercially successful oil field in the Cuyama Valley may be regarded as poor; and it is highly probable that no field comparable to the larger of the present productive fields of California will be found here. It is possible that in a few small areas pools comparable in size to the smaller pools in Santa Clara River valley, in northern Ventura County, may be found, but this possibility does not seem to offer great encouragement for exploratory drilling.

Throughout the field season the writer was assisted by Wallace Gordon, and many of the data here recorded are the results of Mr. Gordon's work. He also wishes to acknowledge the uniform courtesy and hospitality of the inhabitants of the region.

PREVIOUS REPORTS.

Although much of southern California has been studied by geologists, there appears to be very little information published concerning the geology of the Cuyama Valley. The valley was visited in 1854–55 by one of the Pacific railroad survey parties, and the geology is described in a report by Thomas Antisell.[1] He commented on the narrowness of the canyon of lower Cuyama River, above which is the wide valley which he likened to the basin of a great arm of the sea. Antisell gave only a very general statement as to the geologic structure and stratigraphy.

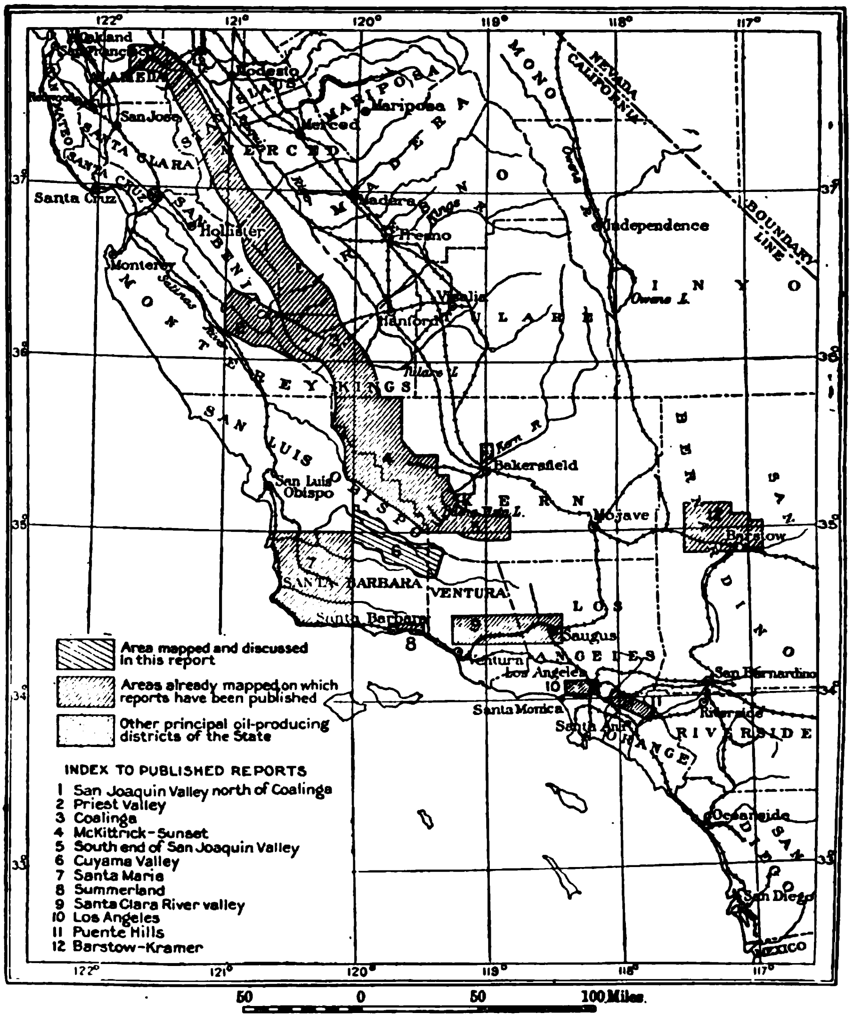

FIGURE 12.—Index map of a part of California.

A paper by Fairbanks[2] describes an analcite diabase which he had observed on the north side of Cuyama Valley.

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[1] U. S. Pacific R. R. Expl., vol. 7, pt. 2, pp. 53–57, 1857.

[2] Fairbanks, H. W., Analcite diabase in San Luis Obispo County, Cal.: California Univ. Dept. Geology Pub., vol. 1, No. 9, pp. 273–300, 1895.

Lawson,[1] in a report on the California earthquake of 1906, gives a brief description of the main physiographic features of this region, and in the same volume Fairbanks describes the rift features along the San Andreas fault.

GEOGRAPHY.

The area of which a detailed study was made and which is shown on the geologic map (Pl. XIX) lies at the south end of the Coast Ranges, approximately 250 miles southeast of San Francisco and 100 miles northwest of Los Angeles. It includes about 300 square miles in Ventura, Santa Barbara, and San Luis Obispo counties. The topography and drainage of this area are shown on the maps of the Santa Ynez, McKittrick, and Mount Pinos quadrangles published by the United States Geological Survey.

The State of California extends along the shore of the Pacific for some 750 miles in a northwest-southeast direction, and its eastern boundary lies 200 to 250 miles back from the coast. Through the central part of the State runs the great interior valley, drained by Sacramento and San Joaquin rivers, bounded on the west by the Coast Ranges and on the east by the lofty Sierra Nevada. At the southeast end of the interior valley the Sierra Nevada narrows and swings southwestward in a broad sweep to meet the Coast Ranges, forming the rugged mountains at the south end of the Great Valley. The area described in this paper lies at the south end of the Coast Ranges, west of their junction with the Sierra Nevada.

The Coast Ranges south of San Francisco are made up of a number of long ridges which trend somewhat more to the west of north than the range as a whole. These ridges reach heights of 4,000 to 5,000 feet and are separated by comparatively wide, alluvium-floored structural valleys that range in altitude from a few hundred feet to 3,000 feet. The larger streams follow the structural valleys for the greater part of their length, but at places they have cut narrow canyons directly across the bordering ranges.

The region represented by Plate XIX includes the large structural Cuyama Valley and parts of the San Rafael and Caliente ranges, which border it. The San Rafael Range, which lies on the southwest side of Cuyama Valley, forms an area of high relief 15 to 20 miles wide, extending in a northwesterly direction across eastern Santa Barbara County. This range is one of the largest and most rugged of the units forming the Coast Ranges in this part of the State. Northeast of and roughly parallel to the San Rafael Range is a succession of valleys and ranges of structural origin. Named from southwest to northeast these are Cuyama Valley, Caliente Range, Carrizo Plain, Temblor Range, and San Joaquin Valley.

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[1] Lawson, A. C., and others, The California earthquake of April 18, 1906: State Earthquake Invest. Com. Rept., vol. 1, pt. 1, pp. 22, 42, Carnegie Inst. Washington, 1908.

The middle course of Cuyama River follows a northwestward-trending broad structural valley some 40 miles in length. In its eastern half this valley is nearly flat for a width of 4 to 6 miles, but toward the west the continuation of its floor has been cut into by the streams, and it is now represented by gravel-covered mesas that slope toward the narrower valley followed by Cuyama River.

There are two good roads from Maricopa, the nearest point on the railroad in the San Joaquin Valley, to the divide at the head of a north branch of the Cuyama; the new grade is about 12 miles long and the old grade up Cienaga Canyon a few miles longer. From the divide down the valley westward as far as the edge of the area mapped, the road is level but sandy. West of the area mapped the road to Santa Maria, on the coast, is said to be poor in the narrow canyon through which Cuyama River crosses the San Rafael Range, and for this reason the main route of travel from Cuyama Valley is to the San Joaquin Valley and not to the coast.

The climate of the Cuyama Valley is much the same as in other parts of the southern Coast Ranges. The annual rainfall is said to average from 10 to 20 inches, subject to considerable variation. In winter the higher ridges are snow covered and light snowfalls are not unusual in the valley bottom. The summer weather is hot and dry. Cuyama River, like many other Coast Range streams, though nearly dry during the larger part of the year, is often impassable for several days after heavy rains.

Except for a few scattered oaks this region is treeless, the hills being covered with more or less brush, the amount depending on the slope, kind of soil, and amount of sunlight. The brush ranges from a scattered growth to an impenetrable tangle of chamisal, scrub oak, and mountain laurel. In general the mountains to the south of the Cuyama Valley are much more brushy than those of the Caliente Range.

The level land in the broad part of the valley produces in wet years good crops of hay, but the frequency of dry years greatly detracts from the value of the land, and only a few hundred acres are farmed. Recently a number of settlers have taken homesteads on the mesas in the western part of the valley and are clearing them of their dense covering of brush. Springs of good water are rare in the older rocks, but between Salisbury Canyon and the Spanish ranch a number of springs issue from the base of the gravel along the lower edges of the broad mesas. At the present time preparations are being made on the Caliente ranch to use the water from a few of these springs to irrigate some 2,000 acres of land on a low river bench, on which

alfalfa will be planted. Although only very locally suited for agriculture, nearly all of this portion of the Coast Ranges is a fair stock range, and cattle raising is the main occupation of the inhabitants.

GEOLOGY.

CONDITIONS OF SEDIMENTATION.

In the Coast Range province conditions of sedimentation were subject to great local variation during the Tertiary period. The variations were necessary results of the constantly changing relations of land and sea caused by the many warping movements to which the province was subjected. Tectonic forces were active, with varying degrees of intensity at different times and in different parts of the Coast Ranges, practically throughout the Tertiary period. There were both widespread movements that elevated or depressed the major part of the province and caused marine waters to retreat from or transgress over most of it, and more local movements that caused the relative elevation or depression of small blocks of the earth's crust within the province. Differential uplifts similar to those that formed the present ranges accompanied the earlier general movements of subsidence and uplift and formed long island ridges in the sea which, during parts of the Tertiary period, covered the Coast Range area and in which the sediments now constituting the Tertiary formations were deposited. The mingling of sediment derived from these islands with that derived from the main land areas, and the effect of the islands of low relief in sheltering certain areas from deposition of such material, produced the puzzling variations in lithology shown by the Tertiary formations.

As a result of the repeated warping movements which the Coast Range region suffered during Tertiary time, land masses of pronounced relief existed for a considerable part of that period. Erosion was active, a large amount of sediment was carried to the areas of deposition, and formations many thousands of feet in thickness were laid down during the same period in which only a few hundred feet of deposits accumulated in more stable areas such as the eastern part of North America.

Exclusive of local movements it is commonly believed that seven or eight rather widespread transgressions and subsequent recessions of the sea can be recognized as having taken place in the Coast Ranges during Tertiary time. However, the recognition of the results of these movements is extremely difficult because of the many local unconformities and variations in lithology. The area here described illustrates the great local variation in formations resulting from such conditions, for although the area studied in the Cuyama

Valley is comparatively small it is impossible to give a general description of the formations occurring there, as features characteristic of a formation at one place are absent elsewhere. The lines separating the formations mapped were selected as far as possible to make the formations correspond in time of deposition to the epochs of general subsidence which have been worked out for the Coast Ranges as a whole. Thus it must be borne in mind that each formational unit is made to include as nearly as possible all beds in the region which were deposited during a certain period of time and that it comprises local members of different lithologic types. Likewise beds included in a single formation may be separated by marked local unconformities and on the other hand the division lines between formations may come at horizons marked by little or no evidence of unconformity.

STRATIGRAPHY.

GENERAL FEATURES.

The general character and local variations of the formations present in the area mapped are shown in Plate XX. Though rocks of Franciscan age (Jurassic?) are widely distributed in the Coast Ranges, they do not crop out and are not known to be present in this area, so that except for a small fault block of granite (pre-Franciscan?) the oldest formation present is a mass, not less than 9,000 feet thick, of rather uniform dark-green shale, the age of which is not definitely known and may be either Cretaceous or early Tertiary (Eocene). Resting on this shale, everywhere with marked unconformity, is the Monterey group (Miocene). The beds present here are of the same age as the Vaqueros formation and Maricopa shale and perhaps part of the Sespe, as that formation is mapped in the Santa Clara River valley.[1] The Monterey group here consists of a maximum of 8,000 feet of gray and pinkish shales, together with red and white sandstones. Locally unconformable but, in general, apparently conformable above the Monterey group is the Santa Margarita formation (Miocene), composed of white clay and diatomaceous shale, together with white sand and conglomerate formed largely of granitic material. A marked local unconformity separates the lower part of the Santa Margarita from the upper part. Resting on the eroded edge of the Santa Margarita, and with much lower dips, is the Cuyama formation (Pliocene?), which consists of 500 to 600 feet of nonfossiliferous yellow and pink clays, sand, and gravel, in large part of nonmarine origin. Quaternary terrace gravel, important with relation to water supply, covers the dissected surface of a former wide valley in the western part of the area

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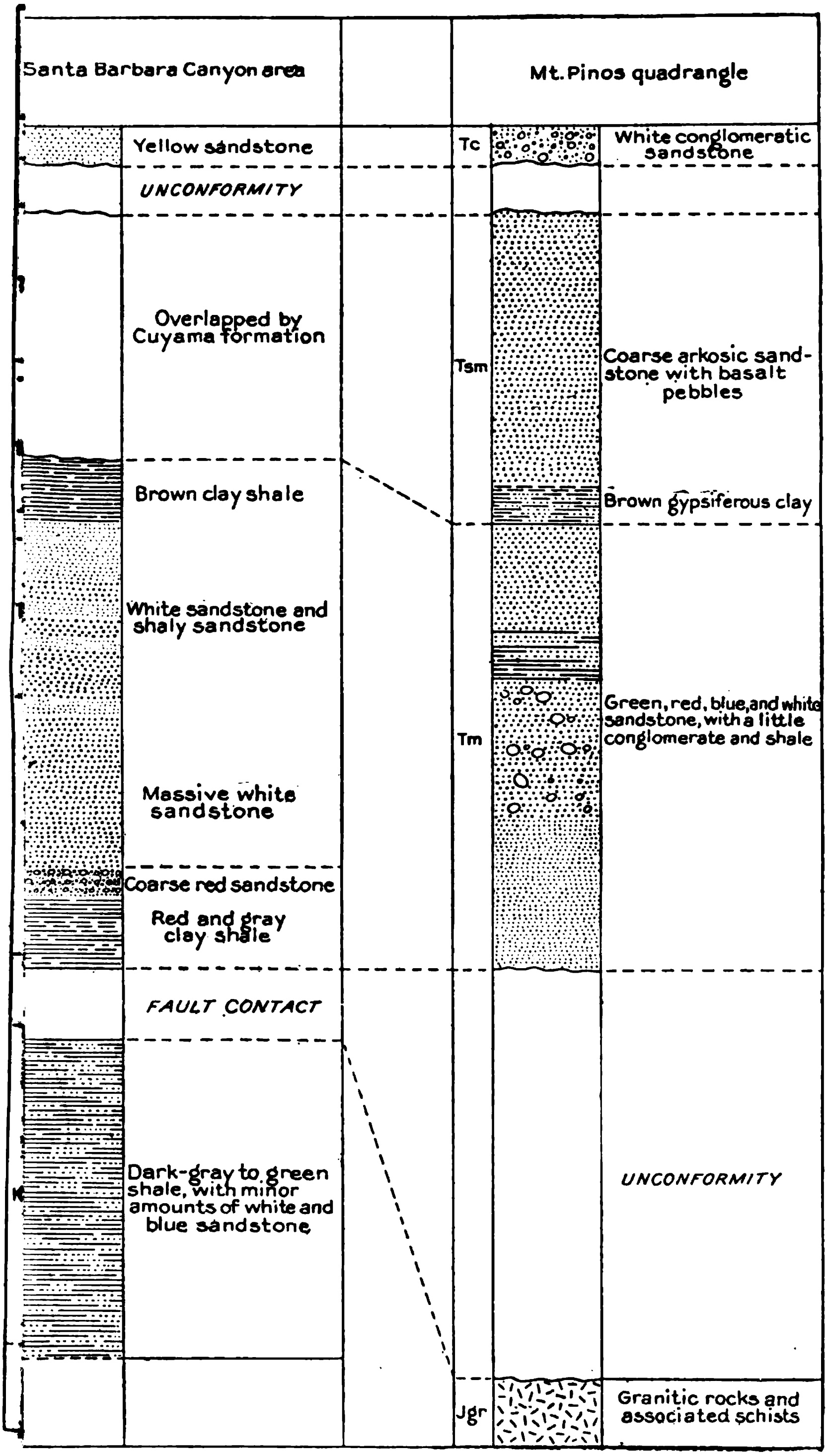
[1] U. S. Geol. Survey Bull. 309, 1907.


Santa Barbara Canyon area
Mt. Pinos quadrangle
Yellow sandstone
UNCONFORMITY
Overlapped by Cuyama formation
Brown clay shale
White sandstone and shaly sandstone
Massive white sandstone
Coarse red sandstone
Red and gray clay shale
FAULT CONTACT
Dark-gray to green shale, with minor amounts of white and blue sandstone
Tc
White conglomeratic sandstone
Tsm
Coarse arkosic sandstone with basalt pebbles
Brown gypsiferous clay
Tm
Green, red, blue, and white sandstone, with a little conglomerate and shale
UNCONFORMITY
Jgr
Granitic rocks and associated schists

CAL.

mapped and is also present near Ballinger and Quatal canyons, where it occurs as scattered remnants of once extensive land-laid deposits formed on an old surface of low relief.

GRANITIC ROCKS.

Near the head of Quatal Canyon is a small fault block of a crushed gneissoid granitic rock, which consists largely of feldspar, hornblende, and mica. This is the only outcrop of granitic rock known to occur between the westernmost exposure of the granite of the Sierra Nevada, about 5 miles to the northeast, and the extensive area of granitic rocks in the Huasna quadrangle, about 50 miles to the northwest. The granite of the Sierra Nevada is intrusive into the Mariposa slate (Upper Jurassic) and is considered to be of Jurassic or post-Jurassic age. It is supposed by many that the granite of the Coast Ranges, though not actually continuous in outcrop with that of the Sierra Nevada, is of the same age, but others regard it as possibly pre-Jurassic.

PRE-MONTEREY SHALE.

A formation not less than 9,000 feet thick, of rather uniform dark marine clay shale, containing a small amount of thin-bedded sandstone, crops out over a considerable part of the area mapped. A poorly preserved Pecten and the cast of a Cerithium, the only fossils found in this formation in the Cuyama area, give no definite evidence as to its age. In adjacent regions there are lithologically similar formations of both Cretaceous and Eocene age, and the formation here present may be of either age, or possibly grade from one to the other. The term pre-Monterey is used in the absence of more definite evidence as to the age of the formation. This formation is continuous with beds in the northeast corner of the Lompoc quadrangle, mapped by H. R. Johnson[1] as pre-Monterey and said to include rock of Knoxville age (Lower Cretaceous), together with Chico (Upper Cretaceous) or Eocene, or perhaps both. Specimens of Aucellæ, characteristic of the Knoxville, were the only fossils found in that area. About 25 miles south and southeast of the Cuyama Valley are the Summerland[2] and Santa Clara River valley[3] oil fields. In these areas the name Topatopa formation is applied to dark-colored shale and sandstone, the upper part of which contains well-preserved Eocene fossils, though the lower part is nonfossiliferous. The Topatopa formation may be of the same age as the beds in the Cuyama Valley, but no definite correlation can be made at present. East of the Cuyama Valley, around the south end of the San Joaquin Valley, is the Tejon formation (Eocene), which consists of about 4,000 feet of greenish and gray sandstone and shale that are lithologically somewhat similar to a part of the pre-Monterey rocks of the Cuyama Valley and may be of the same age.

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[1] Arnold, Ralph, and Anderson, Robert, Geology and oil resources of the Santa Maria oil district, Santa Barbara County, Cal.: U. S. Geol. Survey Bull. 322, pl. 1, 1907.

[2] Arnold, Ralph, Geology and oil resources of the Summerland district, Santa Barbara County, Cal.: U. S. Geol. Survey Bull. 321, 1907.

[3] Eldridge, G. H., and Arnold, Ralph, The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California: U. S. Geol. Survey Bull. 309, 1907.

In the area mapped the nearly uniform character of the dark clay shale is in contrast to the great local variation in lithology of the younger formations. Shale forms about 90 per cent of the formation near Cuyama Peak, the remaining 10 per cent being made up of hard white sandstone which weathers to brown and which is interstratified with the shale in beds varying from 3 to 10 feet in thickness. Farther west, near Aliso Canyon, most of the sandstone when fresh is of a light-blue color and weathers to mottled brown and white, and a few thin beds of conglomerate containing pebbles of metamorphic rocks are present. Near Saltos Canyon the shale is interbedded with sandstone or graywacke, blue when fresh but weathering brown, the color being due to the large amount of ferromagnesian minerals present. About 8,000 feet of this formation is exposed between Cuyama Peak and the fault to the northeast, and a thickness of 9,000 feet was measured in Saltos Canyon, near the west edge of the area mapped. Neither of these sections includes the lowest or the highest beds of the formation, so that the total thickness is unknown and probably is considerably greater than the 9,000 feet measured.

MONTEREY GROUP.

The term Monterey group is here applied to some 7,000 to 8,000 feet of beds of locally variable lithology, which rest with marked unconformity on the pre-Monterey shale. The lower part of the group is correlated with the Vaqueros formation, and the upper part with the Maricopa shale[1] of the southwest edge of the San Joaquin Valley. Though these correlations are believed to be roughly correct, the beds in the Cuyama Valley are not the precise equivalents in time of deposition of these formations, nor are they of identical lithologic character at their type localities. The shale, which is here called Maricopa, probably includes lower rocks than the formation near Maricopa and farther east. In the Caliente Range lava flows and intrusions of basalt or diabase are associated with the upper part of the Maricopa shale, whereas in the San Emigdio Mountains, east of Maricopa, a considerable thickness of beds mapped as Vaqueros overlie similar igneous flows and separate them from the shale there mapped as Maricopa.

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[1] The name Maricopa shale is used in the report on the Sunset-Midway region, now in preparation by R. W. Pack, for a great thickness of diatomaceous shale which in the preliminary report was mapped as Monterey shale.

North of Cuyama River the Monterey group consists largely of dark-gray shale of the Vaqueros in the lower part, and chocolate-colored to pink Maricopa shale in the upper part; south of Cuyama River the Vaqueros is mostly white and red sandstone, and the upper part of the Monterey (Maricopa shale) is brown clay shale, locally grading into white sandstone; east of the upper part of Cuyama River the Monterey group consists entirely of gray, green, red, and white sandstone and arkosic sandstone. Because of these local variations in lithology the three areas of outcrop of the formations of the Monterey group will be described separately.

In the Caliente Range, north of Cuyama River, the Vaqueros formation consists of dark-gray marine clay shale with a small amount of interbedded white sandstone and is overlain by the yellow and pink to chocolate-colored, somewhat diatomaceous Maricopa shale. A section through Caliente Mountain gives a thickness of 6,000 feet of the dark shale of the Vaqueros, though the base is not exposed, the lowest beds cropping out being those next to the fault in the southwestern part of sec. 21, T. 11 N., R. 27 W. The lower 1,500 feet in this section consists of nearly black clay shale without sandstone, above which lenticular beds of white sandstone from 2 to 25 feet thick make up 10 to 15 per cent of the total thickness. The formation is well exposed on the steep slope of the south flank of Caliente Mountain. Similar interbedded shale and sandstone crop out for a distance of 1½ miles down the northeast slope of the mountain.[1] The Maricopa shale conformably overlies the dark-gray clay shale and sandstone of the Vaqueros on both flanks of the Caliente Mountain uplift. On the south flank there is about 2,000 feet of shale weathering pink to chocolate-colored, prevailingly clayey but in part a "chalky" diatomaceous shale. Lenses of hard yellow-weathering impure limestone are numerous. On the northeast side of the Caliente Range about 2,000 feet of similar beds are associated with both interbedded and intrusive basic igneous rocks.

South of Cuyama River the Monterey group consists in ascending order of the Pato red member of the Vaqueros, made up of gray and red clay shale and sandstone; white sandstone of the Vaqueros; and brown Maricopa shale. The massive pure-white sandstone of the Vaqueros is the only part of the group which is sufficiently uniform to be recognizable throughout this area. This sandstone, which contains a good marine fauna of lower Miocene age, is formed of material derived largely from the erosion of granitic rocks. It has a maximum thickness of about 1,300 feet and is especially prominent in the region of Montgomery Potrero and the head of Castro Canyon, where it weathers to extremely rugged white cliffs that may be seen for a distance of 15 or 20 miles. On the southwest slope of Fox Mountain and west of Branch Canyon it was deposited on the pre-Monterey shale, but elsewhere it is underlain by red sandstone and conglomerate which form the lowest member of the Vaqueros formation.

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[1] The writer's work extended only as far north as the crest of Caliente Mountain, and the data concerning the north flank of the mountain are furnished by R. W. Pack, who, in company with Robert Anderson, made a reconnaissance of the south side of the Carrizo Plain in 1909.

East of Santa Barbara Canyon the Vaqueros formation can be divided into two parts, white sandstone above and red sandstone, conglomerate, and clay below. The red rocks are so conspicuous that they have been mapped separately and called the Pato red member of the Vaqueros formation, from Pato Canyon, where they are well exposed. The Pato red member has a thickness of 1,300 feet. The upper 500 feet of beds are of a brilliant crimson color and are composed of material eroded from the adjacent land at the time the red beds were being deposited, the red color being due to the oxidation of the abundant ferromagnesian minerals composing the pre-Monterey rocks. Conformably below the bright-red beds is about 800 feet of gray and red clay. These beds are in fault contact with the pre-Monterey shale, and their base is not exposed.

The absence of red beds west of Fox Mountain is believed to be due to a conformable overlapping of the red beds by the white sandstone of the Vaqueros, the Fox Mountain area having been land at the time the Pato red member was deposited and having furnished the material of which it was formed.

In the vicinity of Montgomery Potrero the massive white sandstone of the Vaqueros is underlain by a pearl-gray shale, partly "chalky" and made up of diatom skeletons, at the base of which is locally about 150 feet of red beds formed of material derived from the underlying pre-Monterey rocks. The maximum thickness of this shale that was noted is 1,800 feet. As this shale is not of a lithologic type which would normally have been deposited in an area of progressive overlap upon an uneven land surface, its irregular distribution suggests that it is uncomformable below the white sandstone, though for the present purpose it is included with the Pato red member of the Vaqueros formation.

The Maricopa shale, which overlies the white sandstone of the Vaqueros formation south of the Cuyama Valley and which forms the upper part of the Monterey group, has been mapped separately only as far eastward as Salisbury Canyon. It consists of about 1,700 feet of brown shale in which reef-like outcrops of white sandstone are locally prominent. The shale is made up mostly of clastic fragments, locally clayey, and is not noticeably diatomaceous. East of Salisbury Canyon the upper part of the Monterey group consists largely of white sandstone and is not separable from similar beds which underlie it.

In the northeastern part of the area mapped there is about 7,500 feet of nonfossiliferous bright-colored sandstone, which is believed to be roughly equivalent to the Monterey group in the areas to the west. These beds, though prevailingly marine, are coarser grained than those to the west, and were undoubtedly laid down closer to the shore line. The following description gives the character of the beds exposed along the line of section B–B′, Plate XXI: The lowest beds, which crop out close to the San Andreas fault, consist of a greenish sandstone, composed of ill-sorted quartz grains, interstratified in beds 4 or 5 feet thick, with finer and softer gray sandstone. Though the irregular structure makes estimates of thickness uncertain, there is probably about 2,000 feet of these lower beds exposed. Above them is 800 feet of prevailingly massive sandstone, gray to grayish green, varying to a bright red. This sandstone is a prominent feature on both flanks of the steep anticline north of Ballinger Canyon, where it forms wall-like outcrops and prominent cavernous rocky points. Above it is 900 feet of more varicolored blue, red, and gray sandstones and sandy clays, consisting of rather ill-sorted material and containing bowlders of schist and granite, some of which are 6 feet in diameter. These beds and those overlying them are softer than the lower sandstone and weather to badlands, with steep slopes and narrow, nearly impassable gulches. At the top of the bright-colored sands there is a locally prominent bed of yellow sandstone, 50 feet thick, overlying which is about 600 feet of bluish sandy shale, that weathers to a light brown. Above the shale is 200 feet of soft, nearly white sandstone, in which a few thin calcareous beds stand out prominently. The white sand grades upward into similar white and ocher-colored sand and conglomerate which contain lenses of yellow clay, in all probably about 2,000 feet thick. In these beds the material is poorly sorted and the grains are only slightly rounded. They are evidently the products of rather rapid erosion from near-by areas of considerable relief, and are probably, in part at least, of nonmarine deposition. In the eastern part of the area mapped, very close to the upper limit of these beds, is a 20 to 40 foot basalt flow, interbedded with the yellow and white arkosic sands.

The following fossils were found close to the base of the white sandstone of the Vaqueros near Santa Barbara Canyon:

Pecten magnolia.
Pecten bowersi.
Pecten volæformis.
Turritella inezana.

The following were found near the top of the Vaqueros formation southeast of Caliente Mountain:

Chione panzana?
Chione n. sp., near diabloana.
Mytilus mathewsoni var. expansus.
Panopea estrellanus.
Pecten crassicardo.
Calyptræa sp.?
Murex vaquerosensis new var.
Trophosycon sp.?
Turritella ocoyana.

In the upper part of the Monterey group south of the Cuyama Valley the following occur:

Scutella norrisi.
Chione securis.
Ostrea veatchii?
Pecten andersoni
Phacoides acutilineatus.
Venus pertenuis.
Turritella ocoyana.

SANTA MARGARITA FORMATION.

The Santa Margarita formation, consisting of 2,000 to 4,000 feet of light-colored sand and shale, rests with apparent conformity on the underlying Monterey group, though the overlap of the Santa Margarita on the pre-Monterey rocks in the western part of the Cuyama Valley shows that it is at least locally separated from the Monterey group by an unconformity. In the western part of the area mapped the Santa Margarita formation consists of a basal red sandstone, overlain by interbedded diatomaceous shale and white sandstone containing a characteristic marine fauna, and this in turn is overlain by clay, sand, and gravel. The beds mapped as Santa Margarita east of Cuyama River are nonfossiliferous coarse white sand, gravel, and brown clay, lying conformably on the underlying Monterey group.

The basal red sandstone, having a thickness of 500 feet, is limited to a small area in Redrock Canyon. Because of its marked difference in color from the remainder of the formation and because it represents a phase of sedimentation that is important in a study of the geologic history of the region, this red sandstone has been mapped and is here named the Redrock Canyon sandstone member of the Santa Margarita formation.

The Redrock Canyon sandstone consists of bright-red sandstone, clay, and conglomerate, the materials of which were derived from an adjacent land mass of pre-Monterey rocks, and the deposition of materials of this kind ended when the land was overlapped. The color of this member, like that of the Pato red member of the Vaqueros formation in Santa Barbara Canyon, is due to the oxidation of ferromagnesian minerals in the fragments of sandstone of the pre-Monterey rocks, of which the member is composed. The Redrock Canyon member rests directly on the pre-Monterey rocks, the absence of the Monterey group probably being due to its removal by erosion before the deposition of the Santa Margarita.

The shale which conformably overlies the Redrock Canyon sandstone represents a more widespread phase of deposition, though it varies considerably in lithologic character in the western part of the Cuyama Valley. Because of its distinctive lithologic character this shale has been mapped separately and is named the Whiterock Bluff shale member of the Santa Margarita formation, from

Whiterock Bluff, on the north side of the Cuyama Valley. Near this point it consists of not less than 1,500 feet of a white "chalky" diatomaceous shale, which is believed to be separated by an unconformity from the Monterey group, upon which it rests. Above this shale is about 100 to 150 feet of fine white sandstone that probably belongs to the overlying member of the formation. Two miles north of Whiterock Bluff the "chalky" shale, which there stands nearly vertical, is about 1,000 feet thick. Farther west, near Taylor Canyon, it is only a few hundred feet thick, and the shale part is underlain by 25 to 200 feet of white sandstone, conformably below which is the Redrock Canyon member. On the south side of the Cuyama Valley the Whiterock Bluff shale, consisting of interbedded white clay shale, diatomaceous shale, and sandstone, apparently grades into the underlying sandstone and shale beds mapped as the Maricopa shale, the line of separation being drawn at the lowest horizon at which Santa Margarita echinoderms occur. Three zones of white sandstone and two zones of shale are present, the total thickness being 2,000 to 2,500 feet, of which the shale makes up about one-third.

The remainder of the formation is called the Morales member of the Santa Margarita because of its development in the vicinity of Morales Canyon, where it consists of some 2,000 feet of clay, white sand, and gravel. It is unconformable on the Whiterock Bluff shale, as is shown by the fact that it overlaps the shale and rests upon the pre-Monterey rocks. The lower part of the Morales member consists of 300 to 400 feet of a light-gray, poorly bedded soft clay shale, containing a few thin beds of white limestone which on weathering break up into small irregular fragments that become scattered over the surface. On the south side of Cuyama River nearly all of the Morales member is of the lower fine-grained phase, but north of the river the lower clay is overlain by 500 to 600 feet of white sandstone and clayey sandstone, above which is 1,000 feet of largely incoherent gravel, which contains abundant shale pebbles, probably derived from erosion of the Whiterock Bluff shale, along with a few large oyster shells that are secondary, being probably also derived from the same member.

In the eastern part of the area mapped the Santa Margarita is represented by about 4,000 feet of nonfossiliferous light-colored gravel and 500 feet of brown clay in which layers of gypsum are interbedded and large secondary crystals of gypsum are common. This zone of brown gypsiferous clay, which rests conformably on the orange-colored and white beds of the Monterey group, is easily traceable and therefore has been somewhat arbitrarily assumed to be the base of the Santa Margarita formation. The gypsiferous clay is only a short distance above the interbedded basalt, which is similar to basic intrusive rocks that are closely associated with the Monterey group in this general region. The gravel above the gypsiferous clay contains basalt bowlders, which are absent at lower horizons, indicating that the upper beds are unconformable upon the beds associated with the basalt flows and belong to a later formation.

The following fossils were found in the Whiterock Bluff shale member of the Santa Margarita formation:

Astrodapsis antiselli.
Astrodapsis tumidus.
Ostrea titan.
Pecten crassicardo.
Trophon gabbianum?
Venus pertenuis.
Agasoma sinuatum.
Turritella carisaensis.
Turritella ocoyana new var.?
Tamiosoma gregaria.

CUYAMA FORMATION.

Beds of nonmarine yellow and pink sands which rest with very marked unconformity on the Santa Margarita and older beds are here named the Cuyama formation, because they crop out only in the Cuyama Valley. This formation was laid down in a broad valley, possibly somewhat wider than the present distribution of the deposits would indicate, which had been eroded in the previously folded and faulted older formations. At the time the Cuyama formation was deposited the main ranges and valleys were much as they are at present, though with less relief, and since its deposition the region has been affected by only minor movements compared to those which disturbed the Santa Margarita and older formations. Because of the low dips, a good section of the Cuyama formation is nowhere exposed. In the eastern part of the Santa Ynez quadrangle the formation is probably not over 250 or 300 feet thick and consists of incoherent yellow sand with here and there a shale-pebble conglomerate, probably in large part a river deposit. Farther west, where these beds are probably twice as thick, the sand is pink, poorly sorted, and in part clayey. This is presumably a playa or estuarine deposit.

No fossils were found in the Cuyama formation. Its deposition was probably coincident with the formation of the extensive Santa Lucia peneplain, which was described by Fairbanks in the San Luis folio[1] and which he believed to be of Pliocene age.

TERRACE GRAVEL.

The Cuyama formation was gently folded and faulted, after which a second wide valley was cut in the Cuyama structural trough. In this valley from 10 to 50 feet of orange and ocher colored gravels were laid down as an alluvial apron sloping from the foot of the adjacent ranges toward the middle of the valley. Since that time

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[1] Fairbanks, H. W., U. S. Geol. Survey Geol. Atlas, San Luis folio (No. 101), 1904.

Cuyama River has cut its channel below the gravel-covered surface of the western half of this old valley, and fragments of the former valley bottom now form mesas separated by narrow steep-sided gulches. During this process of downward cutting by Cuyama River a number of intermediate river benches or terraces were formed and gravel was deposited on them. Thus the terraces are of various ages, some of them having been formed long ago and some very recently, During the most recent period of downward cutting, which probably commenced not over a few hundred years ago, Cuyama River has carved a narrow channel, with vertical sides 15 to 30 feet high, in the western part of the area mapped.

TERTIARY IGNEOUS ROCKS.

In the southern part of the Coast Ranges small flows and intrusions of basic igneous rocks are commonly associated with beds of the Monterey group. West of the Caliente Range a basic rock described by Fairbanks[1] as analcite diabase is intrusive into the Maricopa shale of the Monterey group. The areas of intrusive rocks are so small and irregular in outline that it is very difficult to map them, and only two such areas are shown on the map accompanying this report. On the north side of the Caliente Range a similar rock forms a number of flows of considerable size in the Maricopa shale and is associated with similar intrusives. Just west of the small block of granite in Quatal Canyon a basalt flow 20 to 40 feet thick and about 2 miles long is interbedded near the top of the Monterey group.

STRUCTURE.

GENERAL STRUCTURE OF THE REGION.

The Coast Ranges of California are made up of a series of long northwestward-trending ridges, the individual ranges of the system, separated by wide valleys. These ridges and valleys are of structural origin, having been formed by the folding and faulting that accompanied the general uplift which, near the close of Pliocene and during early Pleistocene time, raised the Coast Ranges to their present altitude. Though subsequent erosion has cut gulches and canyons in the ranges, the main topographic features are still clearly structural, and the larger streams, for most of their courses, follow the structural valleys. Where streams cut across structural ridges, the narrow canyons that they follow are in striking contrast with the wide valleys that trend parallel to the structure, showing what a small part of the width of the valleys can be due to erosion.

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[1] Fairbanks, H. W., Analcite diabase in San Luis Obispo County, Cal.: Univ. California Dept. Geology Pub., vol. 1, No. 9, pp. 273–300, 1895.

When examined in more detail the main ranges and valleys are seen to have a more complex structure than would result from a single epoch of folding and uplift. The structure above outlined as resulting from the comparatively recent folding is superimposed upon structures formed by earlier movements, the present complexity being the result of several movements during Tertiary time. An interesting result of this combination of movements is that, although the general trend of the major lines of structure produced by the earlier movements was northwest and thus parallel to the major lines of the present structure, the blocks subjected to differential uplift during the earlier part of the Tertiary were in many places not the same as those which have been most recently uplifted. Moreover, the relative movement of any particular area has not always been in the same direction, for at one time it may have formed part of a block that was depressed and at another time part of a block that was elevated with respect to adjacent blocks. Thus the area recently faulted down to form the western part of the Cuyama Valley was at an earlier time uplifted, and the Monterey group was removed from it by erosion, while the area of the present Caliente Range was either under water or subjected to much less erosion.

The main structural features of the area mapped (see Pl. XXI) are the structural depressions of the Cuyama Valley and the upfolds or uplifted blocks of the earth's crust on both sides, forming the Caliente and San Rafael ranges. The Caliente Range was formed largely by the folding of the rocks, but this folding was accompanied in places by breaking, producing faults. Two strike faults along which the rocks moved at least 1,000 feet bound the Cuyama trough on the southwest through most of its length. Between Branch and Castro canyons, however, there are no faults, and the Monterey group extends in unbroken outcrop southward to the crest of the ridge. A number of cross faults north of Montgomery Potrero bound the east end of the great block of uplifted pre-Monterey rocks, against which the beds of the Monterey group are faulted down. From Castro Canyon eastward the other large strike fault has brought the pre-Monterey rocks up on the south. Here the main fault dies out toward the west, and there are no cross faults, the Maricopa shale resting with normal contact upon the southwest side of the tilted block of pre-Monterey rocks.

The structure of the east end of the Cuyama Valley is obscured by the heavy cover of alluvium, but the topographic form of the valley, together with the presence of a broad, open syncline that crosses Quatal Canyon, a mile above its mouth and directly in line with the axis of the valley, strongly suggest that this part of the valley is also synclinal.

DETAILS OF STRUCTURE.

The complex anticlinal structure of the Caliente Range includes a number of folds, of which the largest two in the area mapped cross the range at a considerable angle, trending more nearly north than the range as a whole. The dips on the north flank of the great fold and on the upper slopes of the mountain are not over 30°, but on the south flank, or the side of the mountain facing the Cuyama Valley, the dips vary from 75° S. to vertical, or the beds are in places even overturned and dip steeply toward the north. The great fold composing the mountain is thus asymmetric, the dips on one side being very much steeper than those on the other side. Northwest of Whiterock Bluff the Caliente anticline is separated from the Cuyama trough by a fault which has brought the Maricopa shale into contact with the Morales member of the Santa Margarita formation.

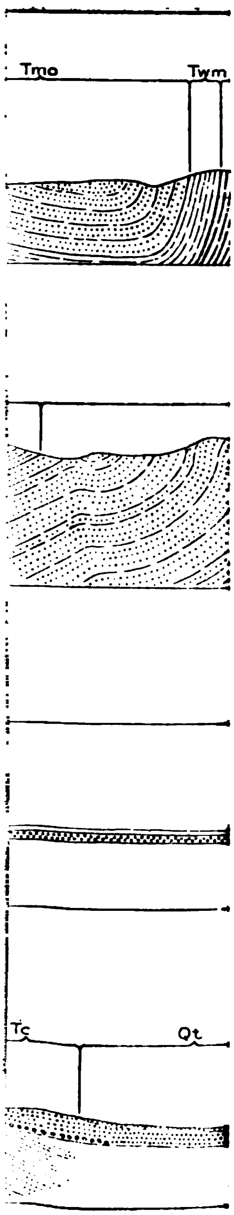
A block which was depressed as a structural unit in the last great epoch of deformation lies in the western part of the Cuyama trough, between the fault south of the Caliente Range just mentioned and the great fault southwest of the Cuyama trough, and extends from Aliso Canyon northwestward beyond the edge of the mapped territory. In this area the Santa Margarita formation, where its base is exposed, rests directly on the pre-Monterey shale, and the Monterey group does not appear to be present. The dips in the shale of the older formations range from 35° to 70° SW., whereas those in the overlying Santa Margarita are generally less than 20°. The broad folds into which the Santa Margarita is here flexed are striking when contrasted with the close folds and steep dips shown by the same formation in other parts of the trough. The absence of the Monterey group in this great fault block indicates that after the deposition of that group the block was raised above the adjacent area, now occupied by the Caliente Range, and the Monterey group was removed by erosion. The pre-Monterey rocks thus exposed were also reduced by erosion to a region of low hills on which the Santa Margarita formation was deposited when the land again became submerged. A later movement in the opposite direction brought the block down to its present position in the trough, faulting the gravel of the Morales member against the pink Maricopa shale. It is possible that the uplift on the northwest side of this block was accompanied by a downward movement along the plane of the fault that now bounds the block on the southwest, and if so there may be a strip of the Monterey group along the southwest edge of the tilted block, which escaped erosion and is now concealed by later deposits.

There have been two later movements along this fault on the southwest side of the Cuyama trough. The earlier one preceded the deposition of the Cuyama formation and formed an uplifted block from which material was derived to form the bowlder beds in that formation near the fault. The later movement faulted the Cuyama formation and left the steep scarp which now exists along this fault line.

On the south side of Cuyama River, east of Aliso Canyon, the Monterey group and Santa Margarita formation are flexed into fairly steep folds, the general character of which is illustrated by section B-B′, Plate XXI. The beds that compose the Santa Margarita formation are, because of their softness, more irregularly folded and faulted than those of the Monterey group. Only a few of the individual folds and faults will be described. The white sandstone which is involved in a sharply folded syncline of the Vaqueros that crosses Santa Barbara Canyon along the south line of T. 9 N. is, in part, faulted down against the Pato red member, and forms a striking feature by reason of the contrast in color between the pure white massive sandstone and the bright-red conglomerate and clay. A very narrow fault block of dark-green or gray to rusty unindurated angular conglomerate, which dips about 20° S., lies between the syncline of white sandstone and the pre-Monterey rocks. These conglomeratic beds evidently originated as a talus deposit along a steep slope produced by an early movement on the main fault, and later the narrow block was faulted down to its present position. The fault that extends eastward from Santa Barbara Canyon, about a mile north of the large fault, has brought the white sandstone down on the north side against the bright-red beds. Throughout this area the older Tertiary rocks are overlain with marked unconformity by the comparatively flat-lying Cuyama formation, in which the dips are mostly under 10°. The plane of contact at the base of the Cuyama is apparently steeper than the dip of the formation, suggesting that the surface on which these beds were deposited was marked by a steep slope near the limit of their present distribution.

No attempt was made to work out in detail the geologic structure in the areas of pre-Monterey rocks which form the rugged mountains on the south side of the Cuyama Valley. The dips in the areas examined suggest that the folds are much larger than those in the later formations, and the structural lines are possibly less markedly northwest in trend.

The largest structural feature in the northeastern part of the area mapped is the broad syncline which crosses Quatal Canyon near its mouth and which is probably a continuation of the Cuyama trough. North of this syncline the sandstone of the Monterey group is flexed into steep and irregular folds and the beds are greatly broken close to the San Andreas fault, which here as elsewhere has formed a zone of very intricate structure a mile or more wide.



OGIC MAP (PLATE

PETROLEUM.

GENERAL CONDITIONS OF OCCURRENCE.

An examination of the geology of the Cuyama Valley was undertaken with the object of determining, so far as it is possible to determine from the study of surface evidence alone, whether or not commercially important quantities of oil might reasonably be expected to occur here. The preceding sketch of the general geologic features is given in order that the reader may understand the reasons for reaching the conclusions stated below.

It must be borne in mind, however, that one can not, from a study of the surface alone, determine positively whether or not oil occurs beneath the surface. It is possible by such a study to designate areas in which it is extremely unlikely that oil may occur, and other areas in which the structure is favorable for the accumulation of oil, but the presence or absence of oil can be definitely determined only by drilling. As the cost of putting down a well is great, drilling should not be undertaken in a new region until a careful geologic examination of the surface has been made and the most favorable area determined, for not only is the chance better for getting oil in that particular area, but if the drill finds the sand dry it is a fair inference that the sands beneath the surrounding areas are also dry. Many wildcat wells, by reason of their poor location, add little or nothing to our knowledge of the oil possibilities of the region other than to show that the particular spot drilled on is not underlain by oil.

CONDITIONS IN PRODUCTIVE FIELDS OF CALIFORNIA.

One of the most significant facts that suggests the occurrence of petroleum in this region is its situation between the very productive Sunset field on the northeast and the Santa Maria field on the southwest, with the smaller scattered fields of the Santa Clara River valley some distance to the south. Therefore a brief statement of the condition under which oil occurs in these productive fields is given for comparison with conditions in the Cuyama Valley.

Oil is known to occur in various sands throughout the Tertiary system in the productive fields of California. Although some oil has been found in older rocks, the Tertiary beds are the most productive, but the precise geologic age of any particular bed within the Tertiary seems to have little or no bearing on the question of its possible petroleum content. Thus beds at the same horizon as the oil sands in an adjacent productive field are not necessarily the beds most likely to yield oil in an undeveloped area. The geologic structure of possible oil-bearing rocks and their association with shale formations which are believed to have been the original source of the oil are of greater importance than the precise geologic position of the rocks.

In the Santa Maria field and the Sunset and other San Joaquin Valley fields the oil-bearing sands are close to large bodies of light-pink diatomaceous shale or "chalk" rock. When this "chalky" shale is examined under a microscope it is seen to contain a great many small, variously shaped objects, which are the skeletons or shells of Radiolaria and Foraminifera, two kinds of small animals that lived in the sea at the time this shale was being deposited. Much more numerous than the animal remains are skeletons which are recognized by their peculiar forms as having been secreted by diatoms, small and very simple marine plants, which were extremely abundant in the ocean at the time the shale was deposited. The great number of animals and plants whose skeletons are preserved, together with others which may have been even more abundant, but which lacked skeletons, sank to the ocean bottom and formed great deposits of slimy mud or ooze. The organic material from this mud, which subsequently became shale, was later changed into the oil that is now found in near-by sandy rocks. That the oil has really come from this shale is shown by the fact that in nearly all the thousands of successful wells drilled in California the oil comes from sands or other porous beds which are either interbedded with or close to diatomaceous shale.

Although oil is still present in much of the diatomaceous shale, it can be obtained in considerable amounts only from porous rocks into which it has migrated from the close-grained shale. All of the sandy beds in contact with the diatomaceous shale are not oil bearing, for factors other than the texture of the rocks control the distribution of the oil and cause its local concentration at certain points in the porous beds, thus forming the pools of the productive fields. The cause of this migration and local concentration of the oil is still an unsettled problem, but from an examination of successful fields it is seen that beds showing certain types of geologic structure are most likely to contain large amounts of oil. One of the most common structural features of the large California oil fields is the unconformable contact at the base of the oil sands, showing that the sands were laid down upon the eroded edges of diatomaceous shale. Apparently this unconformable contact allows the oil, which migrated freely upward along the bedding planes in the shale, to reach the overlying sands. Within these sands the oil has in most places migrated up the rise of the beds in the different folds and collected in anticlines or on the upper slopes of monoclines and at the upper ends of plunging synclines. However, these points of local concentration have no fixed and invariable relation to structure, and in many places no concentration has taken place in sands which are seemingly as favorably situated as other sands that are highly productive.

The oil fields of the San Joaquin Valley are all situated on rather low folds in the foothill belt around the edges of the valley. The oil sands crop out only on the side of the productive areas farther from the valley, and oil may have migrated up from a considerable distance down the dip in the wide San Joaquin Valley syncline. Thus another important condition of productive fields is the presence over a considerable area adjacent to the oil pools of impervious beds overlying the masses of diatomaceous shale.

In the Santa Maria field the oil migrated from bodies of diatomaceous shale and collected in overlying sandstone beds and in bodies of shale which had been previously folded and crushed into angular fragments between which the oil found a resting place. The folds in this field are smaller and the dips steeper than in the San Joaquin Valley fields, and the areas from which oil could have migrated to form the local concentrations are less extensive. Despite this fact there are a number of exceedingly productive local areas in this field.

In the fields of the Santa Clara River valley much of the oil apparently originated in clay shale, possibly in part diatomaceous, and is found concentrated mostly in overlying sandstones, along anticlines, and close to faults. In this field many of the folds in which oil occurs are closely compressed and narrow and are similar in type to the folds which occur in the Cuyama Valley.

Oil seeps are present in the vicinity of all the developed fields, and independent of later developments they prove the presence of at least some oil in the region. Many of the seeps occur along the outcrops of productive oil sands, and thus they also indicate the position of the sand in which the oil occurs. In an undeveloped field the prospector should therefore expect to find oil seeps, and their location should indicate the part of the formation most favorable to prospect. Though many oil pools have been discovered by drilling near seeps and neglecting other features, this has generally proved a costly and roundabout way of eventually discovering the productive areas.

CONDITIONS IN CUYAMA VALLEY.

As the association of sandy beds with the shale which was the original source of the oil is one of the most important conditions in productive fields, the discussion of the Cuyama Valley area will be based on the areal distribution and character of such shale. The shales present in the Cuyama Valley are the thick mass of pre-Monterey shale, the shale in the Vaqueros formation, the Maricopa shale, and the locally well-developed Whiterock Bluff shale member of the Santa Margarita formation.

There appears to be little possibility of obtaining oil from beds associated with the dark clay shale of the pre-Monterey rocks, which crops out over considerable areas in the rugged mountains on the south side and in the western part of the Cuyama Valley. Lithologically similar shale of Cretaceous age on the west side of the Sacramento Valley contains oil seeps, and in the Santa Clara River valley some of the oil probably originated in the Topatopa (Eocene) shale, which is of much the same type and possibly of the same age as the shale of the pre-Monterey in this area. However, in the area examined no seeps or other evidence of the presence of oil were found or were reported in this shale, or in overlying beds, so that it seems unlikely that any appreciable amount of oil derived from it is present either in the interbedded sandstones or in porous overlying formations. Much the same reasoning may be applied to the dark clay shale and interbedded sandstone of the Vaqueros formation, which constitutes the main mass of the Caliente Range.

Of the other formations the pearl-gray shale in the vicinity of Montgomery Potrero, the pinkish Maricopa shale on the flanks of the Caliente Range, and the "chalky" Whiterock Bluff shale member of the Santa Margarita are the only beds that are of a lithologic type in which it seems likely that oil may have originated, and only those general areas in which one of these shales crops out or is believed to be present below the surface are thought to be likely to produce oil.

The gray diatomaceous shale which is mapped as a part of the Pato red member of the Vaqueros and which underlies the prominent white sandstone of the Vaqueros at Montgomery Potrero has a very irregular distribution, being absent along the Monterey and pre-Monterey contact west of Branch Canyon and on the south side of the tilted block of pre-Monterey rocks at the head of Castro Canyon. It probably underlies the western part of the prominent anticline north of Salisbury Potrero, but its slight thickness and meager content of diatomaceous material make it insignificant in comparison with the great mass of diatomaceous shale in productive fields. No seeps are known to occur in this shale or in associated porous rocks. The chance of obtaining commercial quantities of oil from beds overlying this shale in the area mapped is therefore probably slight.

The Maricopa shale, in the upper part of the Monterey group of the Caliente Range, has a maximum thickness of about 2,000 feet, and although less diatomaceous than the typical "Monterey shale" it may have been the source of considerable quantities of petroleum. Two or three oil seeps have been reported in this shale.

The white diatomaceous shale in the Whiterock Bluff shale member is locally over 1,000 feet thick and may have been the source of considerable quantities of oil. It is significant that the seep south of Whiterock Bluff occurs at a point where this shale is thickest as well as most diatomaceous. Areas of favorable structure underlain by either this or the Maricopa shale would deserve very careful consideration as being possibly productive. Unfortunately no such areas of favorable structure were found.

The structure in the Caliente Range is unfavorable for the collection of oil from either of these formations, as they are overlain by porous beds only on the flanks of the anticline, where the beds stand nearly on edge. The Whiterock Bluff shale member of the Santa Margarita west of the fault that trends northwest from the mouth of Morales Canyon is thin but very diatomaceous. However, the broad syncline in which it lies is not a favorable structure for the accumulation of oil.

Between Whiterock Bluff and the outcrop of the Santa Margarita formation, west of Salisbury Canyon, and northward to Cuyama River is an area in which a determination of either the structure or the distribution of the formations that may have been a source of oil is uncertain because of the presence over most of the surface of the Cuyama formation and terrace gravels. As the underlying structure is unknown this area can not be classed as definitely barren of oil, although there is no positive evidence to recommend it as an area favorable for oil accumulation. The small area of pre-Monterey rocks overlain by the Morales member of the Santa Margarita south of Whiterock Bluff is important as showing that the diatomaceous shale does not extend directly south from Whiterock Bluff to the edge of the valley. In the absence of more definite evidence it may be assumed that the diatomaceous shale is absent south of a line drawn from the small area mentioned to the point where Aliso Canyon enters the main body of pre-Monterey rocks. Northeast of that line the Cuyama formation is presumably underlain by one or both of the diatomaceous shale formations. Though probably present both shales become notably less diatomaceous toward the southeast. The Maricopa shale is a nondiatomaceous brown sandy clay shale south of Cuyama River, and the Whiterock Bluff shale between Salisbury and Aliso canyons is less diatomaceous than at Whiterock Bluff. If one may judge of the amount of oil formed in the shale by its thickness and the amount of diatom skeletons present in it, then only a comparatively small quantity of oil should be expected to occur in this area. Any oil which may have originated in these shales might have collected either in interbedded sandstones or at the base of the Cuyama formation, having seeped up from the eroded edge of the underlying shale. A well of comparatively shallow depth located on any one of a number of low local anticlines in the Cuyama formation would test the sands at the base of that formation, as the Cuyama formation in this area is probably not over 200 or 300 feet thick. This thickness of beds would probably not give sufficient covering to retain any large quantity of oil, and the very marked unconformity between the Santa Margarita and Cuyama formations suggests that a large part of the oil might have escaped from the lower beds before the overlying beds were deposited, so that on the whole the prospect of obtaining more than small quantities of oil, if any, in this area is not promising.

OIL SEEPS.

The largest seep reported, and the only one seen by the writer, occurs in the bed of Cuyama River south of Whiterock Bluff. The river has cut down about 20 feet through Quaternary stream deposits and is flowing on bedrock, here diatomaceous shale of the Whiterock Bluff member of the Santa Margarita. During an earlier epoch the river cut down to the same level and formed a much wider valley in which the stream gravel and sand that form the vertical banks of the present stream were deposited. It was during this earlier epoch in which the river flowed upon bedrock that most of the oil now seen at this locality seeped up from the underlying shale of the Santa Margarita. While the river was flowing on bedrock and while it was depositing 3 or 4 feet of sand a number of pools of oil were formed here, some not less than 100 yards across. The oil in these pools saturated the surface sand, which was later covered by sediment and preserved and which is now traceable along the vertical river banks as thin strata of oil sand interbedded with white sand and clay. At one place, which may have been the original seep, an asphalt-like oil has escaped from the underlying shale very recently. The shale near this seep has irregular dips and the oil may have come up along or close to a fault.

At least three seeps of oil are reported in areas of Maricopa shale of the Monterey group in the Caliente Range, but at the time of the writer's visit they could not be located and had probably ceased to flow. A reported seep in a small canyon in the NW. ¼ sec. 15, T. 11 N., R. 28 W., could not be found. There is said to be a small brea deposit on a ridge in the SE. ¼ sec. 14, T. 11 N., R. 28 W. A seep reported in the creek bed near the forks of Taylor Canyon, in the SE. ¼ sec. 24, T. 32 S., R. 19 E., has also apparently ceased to exist.

WELLS DRILLED FOR OIL.

The Webfoot well, in a narrow gulch on the north side of Ballinger Canyon, in the SW. ¼ sec. 2, T. 9 N., R. 24 W., was started about 1905, and drilling continued intermittently for a number of years. It is said to have reached a depth of 1,800 feet without encountering any oil. This well starts in nearly vertical beds of brown sandy shale of the Monterey group.

The Grand Prize Oil Co., composed of Bakersfield and local people, drilled a well in sec. 6, T. 11 N., R. 28 W., at about the same time as the Webfoot well was drilled. This well is said to have reached a depth of 600 or 700 feet without obtaining any oil. It starts in the "chalky" white shale of the Whiterock Bluff shale member of the Santa Margarita and probably reaches the underlying pre-Monterey rock. It is located on the south flank of a broad syncline.

STRUCTURE OF THE BEREA OIL SAND IN THE SUMMERFIELD QUADRANGLE, GUERNSEY, NOBLE, AND MONROE COUNTIES, OHIO.

By D. Dale Condit.

INTRODUCTION.

Within the last 12 years the United States Geological Survey has, from time to time, been engaged in mapping the structural features of oil and gas fields in eastern Ohio and southwestern Pennsylvania. The first work was done by W. T. Griswold, who mapped the Berea oil sand in the Cadiz quadrangle, Ohio, and later supervised the preparation of maps for the Steubenville and Flushing quadrangles. In the meanwhile M. J. Munn, E. W. Shaw, and others carried on similar work in western Pennsylvania.

During the season of 1914 a complete geologic examination of the Woodsfield and Summerfield quadrangles, in southeastern Ohio, was made. In this survey the writer was assisted throughout the field season of four months by R. V. A. Mills and Frank Reeves and for a short time by C. A. Bonine. The results of the examination of the Summerfield quadrangle are set forth in a condensed form in this preliminary paper. A similar report has been prepared for the Woodsfield quadrangle. These advance papers are expected to be followed by a geologic folio and an economic bulletin for the two quadrangles, in which more detailed consideration will be given not only to oil and gas, but also to the general geology of the region, including coal and other mineral resources.

The many courtesies extended by the residents of the region during the work are gratefully acknowledged. Thanks are due in particular to the officers of the Carter Oil Co., Pure Oil Co., and Ohio Fuel Supply Co., and to numerous others who furnished maps, well records, and other information necessary to the successful completion of the work. The accompanying farm map (Pl. XXII, in pocket) was compiled from data furnished by the county engineers. It is somewhat inaccurate in places owing to the conditions of the surveys and county records, which are subject to error, especially in Noble County.

GEOGRAPHY.

Location.—The Summerfield quadrangle (Pl. XXIII, in pocket) includes parts of Guernsey, Noble, and Monroe counties, in southeastern Ohio. Its position and extent are represented in figure 13, which also shows other areas in southeastern Ohio and adjacent portions of West Virginia and Pennsylvania for which similar reports have been prepared.

Transportation facilities.—The Summerfield quadrangle is crossed in an east-west direction by two railroads, the Baltimore & Ohio in the northern portion and the Ohio River & Western in the southern portion. The latter is a narrow-gage line that follows a circuitous route over hills and valleys, with numerous steep grades. The principal villages in the quadrangle are Sarahsville, Summerfield, Quaker City, Salesville, Lore City, and Senecaville. The last named is a mining town within the great Cambridge coal field. The Upper Freeport coal is reached by shafts here and at numerous points to the west. Higher coal beds cropping out in the southeastern part of the quadrangle furnish a convenient source of fuel for the farmers.

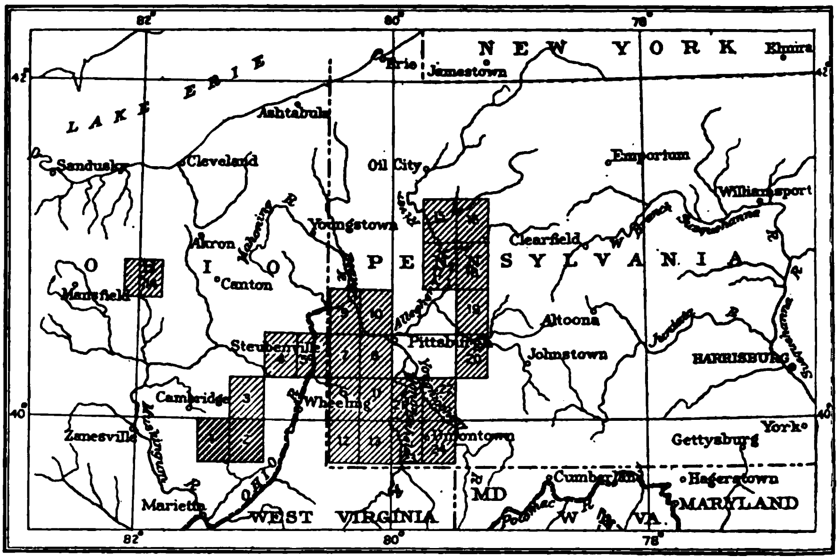


FIGURE 13.—Index map showing location of Summerfield and Woodsfield quadrangles, Ohio (Nos. 1 and 2, heavily shaded), and the names and positions of other quadrangles for which structural maps have been prepared (light shading). 3, Flushing; 4, Cadiz; 5, Steubenville; 6, Claysville; 7, Burgettstown; 8, Carnegie; 9, Beaver; 10, Sewickley; 11, Amity; 12, Rogersville; 13, Waynesburg; 14, Wooster; 15, Foxburg; 16, Clarion; 17, Kittanning; 18, Rural Valley; 19, Elders Ridge; 20, Latrobe; 21, Brownsville; 22, Connellsville; 23, Masontown; 24, Uniontown.

Drainage and relief.—The small areas in the southern part of the quadrangle are drained by Clear Fork of Muskingum River and branches of Duck Creek. These waters follow a rather direct route southward to the Ohio. The greater part of the quadrangle is drained by northwestward-flowing branches of Wills Creek, a tributary of Tuscarawas River. They are sluggish, muddy streams following winding courses in abnormally broad valleys of low gradient. The headwaters divide the hills into numerous parallel ridges of moderate relief, as a rule not more than 350 feet in any one vicinity and only about 480 feet for the entire area.

GEOLOGY.

STRATIGRAPHY.

GENERAL SECTION.

The rocks at the surface in the Summerfield quadrangle are included in the Conemaugh and Monongahela formations of the Pennsylvanian series ("Coal Measures") and the Washington formation of the Dunkard ("Upper Barren") group of the Permian series. Formations below the surface to a depth of 2,000 feet are known through drill records, which show that as to sequence and general composition they agree rather closely with beds that crop out farther west. The dip or slope of the beds is in general southeastward, but there are numerous local variations in the direction and steepness of inclination. These structural features are represented on the accompanying map and are described under the heading "Structure."

The stratigraphy of eastern Ohio has been discussed in detail in previous reports, and only a brief outline is needed here. The several formations represented, with their approximate thicknesses, are listed below. The classification of the beds below the surface is that in use by the Geological Survey of Ohio.

General section of formations in eastern Ohio.

	Feet
Permian series:	
Washington formation ("Upper Barren")	400±
Pennsylvanian series ("Coal Measures"):	
Monongahela formation ("Upper Productive")	255–275
Conemaugh formation ("Lower Barren")	460–475
Allegheny formation ("Lower Productive")	250–265
Pottsville formation	155–170
Unconformity.	
Mississippian series:	
Maxville limestone (Big lime)	0–90
Unconformity.	
Logan formation (includes Keener sand)	600–700
Black Hand formation (includes Big Injun sand)	
Cuyahoga shale	
Sunbury shale	
Berea sandstone	
Bedford shale	

The Washington formation consists largely of sandstone and clay in which reddish or brownish colors predominate, but it also contains thin coal beds and limestone. Rocks of this formation occupy the hilltops in the southeastern part of the area.

The Monongahela formation contains the Pittsburgh, Meigs Creek, and other workable coal beds. These are interbedded with sandy shale, clay, numerous layers of limestone, and a few nonpersistent sandstones.

The Conemaugh formation contains a few coal beds of little economic importance in this region and several persistent beds of limestone. It is for the most part made up of shale and irregular, localized sandstone lenses interlain with clay, which is commonly of a reddish-brown color.

The Allegheny formation is the great coal-bearing formation in the northern Appalachian coal basin. In eastern Ohio, although only a little more than 250 feet thick, it includes numerous coal and clay beds of great economic importance. The Allegheny and lower formations are not exposed within the Summerfield quadrangle. Their sequence is illustrated by well records and by the general section (fig. 15). The thickness of the strata exposed within the Summerfield quadrangle is a little less than 800 feet. The lowest beds appear at the surface along the valleys in the extreme northwestern part of the area and are overlapped southeastward by successively higher and higher beds. The strata below the surface are known through their outcrop elsewhere and through information furnished by the driller.

ROCKS EXPOSED.

The Upper Freeport coal, constituting the uppermost member of the Allegheny formation, lies in the floor of Leatherwood Valley west of Lore City and is mined at Blacktop, Klondyke, and other places to the west and southwest. Over the coal is the Mahoning sandstone, which is well known among oil men on account of its yield of oil at Lore City and other places to the south. This sandstone may be seen in outcrop along the valley about a mile west of Blacktop. The Upper Freeport coal and higher strata are represented in the generalized section forming figure 14. Several beds in this section are especially useful as key rocks to the geologist because of their persistence and easy identification. Some limestone beds that are present throughout the area are in places more satisfactory for use in the mapping of structure than the coals. The more prominent limestones are described briefly.

The Cambridge limestone crops out along valleys in the vicinity of Senecaville and Lore City. Its position is about 155 feet above the Upper Freeport coal. It is a dark-gray, smooth-textured fossiliferous bed easily distinguished from the other limestones. In numerous places it does not appear as a continuous layer but rather as nodules embedded in clay, and in such places the outcrop is not easily discovered.

The Ames limestone crops out over the northwestern part of the Summerfield quadrangle. It is about 110 feet above the Cambridge limestone and 160 to 195 feet below the Pittsburgh coal. It has a granular texture, is highly fossiliferous, and assumes a greenish-gray to rusty-brown surface on weathering. The freshly broken rock is greenish and shows cleavage faces of calcite, cross sections of crinoid stems, to which is due the granular texture. From 15 to 20 feet above the Ames and a like distance below it are somewhat similar but less persistent limestone beds, and care is required not to confuse these with the Ames.

About 25 feet below the Pittsburgh coal is an important limestone member to which the name "Summerfield" was applied by the writer in 1912,[1] but which, being regarded as the same as the Lower Pittsburgh limestone member of the Conemaugh in Pennsylvania, is here designated by the older name Lower Pittsburgh. This rock has a characteristic roughened, lumpy surface that serves to differentiate it from other beds. Marine fossils are lacking in this limestone and all rocks higher in the geologic column in eastern Ohio.

About 25 feet above the Pittsburgh coal is a thin layer of dark

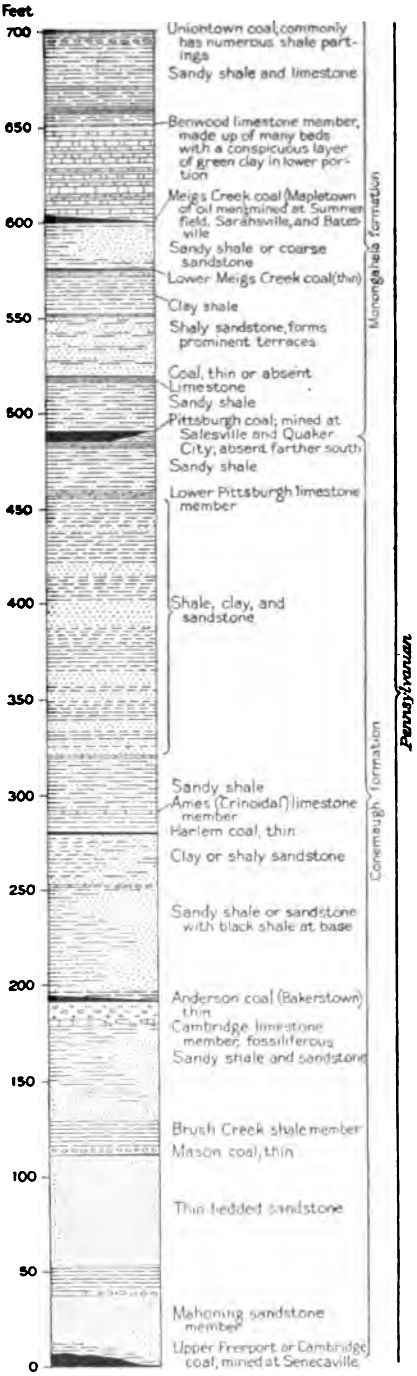

Feet
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
Uniontown coal, commonly has numerous shale partings
Sandy shale and limestone
Benwood limestone member, made up of many beds with a conspicuous layer of green clay in lower portion
Meigs Creek coal (Mapletown of oil men) mined at Summerfield, Sarahsville, and Batesville
Sandy shale or coarse sandstone
Lower Meigs Creek coal (thin)
Clay shale
Shaly sandstone, forms prominent terraces
Coal, thin or absent
Limestone
Sandy shale
Pittsburgh coal; mined at Salesville and Quaker City; absent farther south
Sandy shale
Lower Pittsburgh limestone member
Shale, clay, and sandstone
Sandy shale
Ames (Crinoidal) limestone member
Harlem coal, thin
Clay or shaly sandstone
Sandy shale or sandstone with black shale at base
Anderson coal (Bakerstown) thin
Cambridge limestone member, fossiliferous
Sandy shale and sandstone
Brush Creek shale member
Mason coal, thin
Thin bedded sandstone
Mahoning sandstone member
Upper Freeport or Cambridge coal, mined at Senecaville
Monongahela formation
Conemaugh formation
Pennsylvanian

FIGURE 14.—Generalized section of rocks that crop out in the Summerfield quadrangle, Ohio.

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[1] Condit, D. D., Ohio Geol. Survey Bull. 17, p. 23, 1912.

shale and limestone which apparently lies at the horizon of the Pomeroy coal. This bed and a limestone underlying the Lower Meigs Creek coal are both excellent structural keys.

The Meigs Creek (Sewickley of Pennsylvania) and Pittsburgh are the only important coal beds cropping out in the area. The Pittsburgh coal, which is so valuable to the east in Belmont County, is present over only a few square miles in the northeast corner of the Summerfield quadrangle. It is mined in the hills at Salesville and Quaker City, but to the southwest, where it is geologically due, only black clay or shale marks its place. The Meigs Creek coal is an important source of fuel in the hills north of Batesville and west of Summerfield, but is not present in workable thickness east of Summerfield or to the north in the vicinity of Calais.

In obtaining elevations on the several beds described above many measurements of the intervals between the beds were made. They were found to vary considerably from place to place. The interval between the Lower Pittsburgh limestone and Meigs Creek coal ranges from 118 to 140 feet where measured at six places in Beaver Township, Noble County, and the interval between the Ames limestone and Pittsburgh coal ranges from 160 feet to about 200 feet in the quadrangle.

ROCKS PENETRATED BY THE DRILL.

Rocks not exposed in the area but known through drilling and outcrops elsewhere are, in descending order, the Allegheny and Pottsville formations, of the Pennsylvanian series, and the Maxville limestone and underlying formations, of the Mississippian series. Their sequence is represented by several well records, given below. The numbers assigned to the wells correspond to numbers used on Plate XXII.

Log of well No. 39 (No. 1 on William Secrest farm), Senecaville.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand and gravel	18	0-18	Sand, blue, limy	6	221-237
Cambridge limestone	4	18-22	Shale	13	237-250
Shale, light red	38	22-60	Slate	18	250-268
Slate	40	60-100	Coal [Lower Kittanning?]	1	268-269
Sand	69	100-169	Fire clay	1	269-270
Coal marker	....	169	Sand, dark	5	270-275
Fire clay	20	169-189	Fire clay	6	275-281
Sand	27	189-216	Sand, show of oil	4	281-285
Coal [Lower Freeport?]	2	216-218	Fire clay.		
Fire clay	3	218-221			

Log of well No. 126 (No. 2 on Silas McLoughlin farm), sec. 19, Seneca Township, Noble County.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Ames limestone	3	45-48	Sand (record incomplete).		
Shale	57	48-105	Sand	20	680-700
Sand	55	105-160	Shale	100	700-800
Fire clay, bad cave (record incomplete).			Sand	20	800-820
Sand	55	275-330	Shale	47	820-867
Fire clay	10	330-340	Sand, Keener (show of oil at 878 feet)	143	867-1,010
Sand	10	340-350	Shale	15	1,010-1,025
Shale	15	350-365	Sand, Big Injun	10	1,025-1,035
Coal marker		368	Shale	391	1,035-1,426
Sand, show of gas	62	368-430	Berea sand (oil at 1,432 feet).		
Shale	45	430-475	Total depth		1,436

Log of well No. 535 (No. 1 on M. A. Rader farm), near Summerfield.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Coal, Mapletown or Meigs Creek	4	0-4	Big Injun sand, white	25	1,090-1,115
Coal [Lower Freeport?]	4	722-726	Big Injun sand, black	45	1,115-1,160
Coal [Middle Kittanning?]	4	771-775	Big Injun sand, white	123	1,160-1,283
Stray sand	15	775-790	Lime and shale	264	1,307-1,571
Schramm sand	40	835-875	Slate and lime	55	1,571-1,626
Big lime	25	960-985	Berea sand (gas)		1,669
Keener sand	12	1,070-1,082	Total depth		1,676

OIL AND GAS SANDS.

Few other oil fields have as many producing sands as are found in southern Noble County and the adjacent portion of Washington County, to the south, there being at least ten sands that are productive at one place or another in this area. However, many of these have proved of little importance, and the principal sands in the Summerfield quadrangle are only five in number. These, named in ascending order, are the Berea, Big Injun, Keener, Big lime, and Buell Run sands. The chief objective sand in the search for oil in this quadrangle is the Berea, well known from exposures at Cleveland, Ohio. A few wells have been drilled deeper than the Berea sand; these, with two exceptions, prove that the Berea is underlain by a great thickness of shale practically devoid of oil-bearing sands in eastern Ohio. The Clinton sand, which yields much oil and gas in the central and northeastern parts of the State, lies at least 3,000 feet below the Berea sand, if present in this area.

Names are applied by oil men to nearly every sand penetrated in drilling, and these sands, together with the associated coals and limestones, are represented in figure 15. The oil men are far from consistent in their use of several of the names applied in the section. For example, the term Second Cow Run is applied to almost any

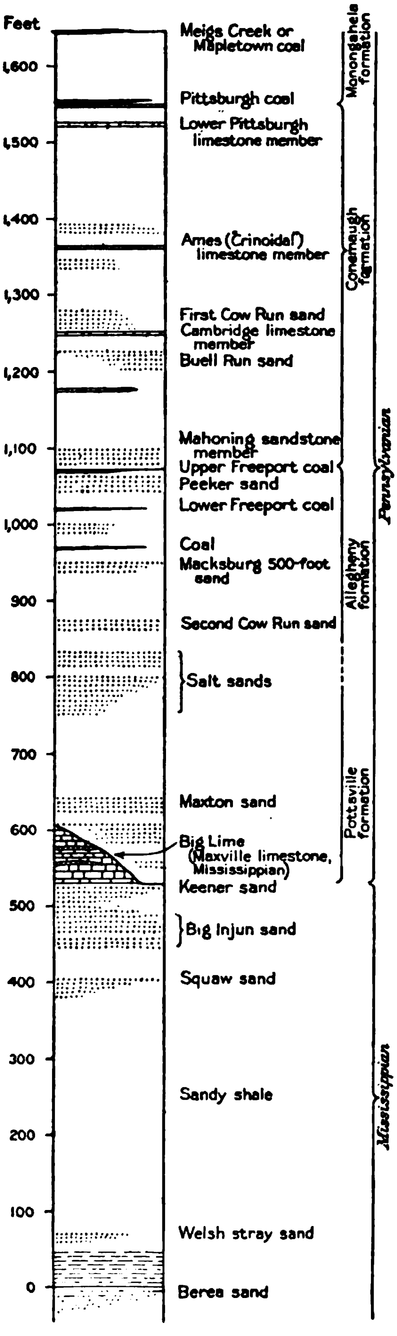

FIGURE 15.—Generalized geologic section showing oil sands of Summerfield quadrangle, Ohio.

sand 100 to 500 feet below the First Cow Run. Names applied to the sands in the Summerfield quadrangle are in part derived from the Macksburg and other pools in Washington County, Ohio, and in part from localities in western Pennsylvania and northern West Virginia. The same sand may be designated by several names in different localities. The confusion of terms is to be expected, for none of the sands maintain a uniform thickness over any considerable area, and in not a few places several of them are found combined into one great mass of sandstone. Locally, the sands are "broken" into a series of alternating beds of shale and sàndstone or are even entirely missing and only "shells" are recorded in their places.

No large oil pools have been discovered in the Summerfield quadrangle, but a considerable area still remains untested. The principal production is limited' to three fields—one at Chaseville, where there are several dozen small oil and gas wells; a second, the Smith pool, in the Buell Run sand, near the southwest corner of the quadrangle; and the third in the vicinity of Summerfield, where one of the most valuable and enduring gas fields yet found in the Berea has been developed.

The Berea sand is probably the most important source of oil and gas in southeastern Ohio. It is the principal productive sand in the great Scio pool, in Harrison County; the Macksburg pool, in

Washington County; and the "Grit" pool at Woodsfield, Monroe County. The position of the Berea is about 1,375 feet below the Ames or "Crinoidal" limestone at Chaseville, and 1,550 feet below the base of the Pittsburgh or No. 8 coal at Quaker City. At Summerfield it is about 1,665 feet below the Meigs Creek or No. 9 coal (Mapletown). The distance of the Berea below the beds near the surface is far from uniform, varying as much as 80 feet in the Summerfield quadrangle and several hundred feet in other quadrangles. The correction in the mapping of the Berea necessary because of this variation in interval is described on page 227.

The Berea varies considerably in thickness, being at most 48 feet, as found in the Chaseville field, and diminishing to less than 10 feet near Salesville. In texture also the sand varies widely from place to place, being locally so shaly and fine grained that it is recorded as "shells" or "no sand" by the driller. Elsewhere it may contain several feet of gray to white fine-grained sand which is known as the "pay." Some wells pass through several of these porous layers interbedded with dense impervious layers. The position of the pay sand varies, being near the top of the formation at Summerfield and near the bottom at Chaseville. Immediately above the Berea sandstone is the black Sunbury shale, which is persistent throughout eastern Ohio and which serves the driller as a notice of the nearness of the Berea sand.

The Big Injun sand is, in general, coarser textured than the Berea and commonly contains quantities of salt water, which not infrequently brings to an untimely end the yield of gas and oil found within the sand. The sand is the source of a small quantity of oil at Brister, 3 miles east of Summerfield, and yields gas at several points near Summerfield and at Chaseville. It has generally one or more shale "breaks" but in some wells is recorded as a continuous bed 200 feet thick, though here and there it is almost entirely replaced by shale. This great diversity is not peculiar to the Big Injun but is characteristic of all sands in the area, especially those in the "Coal Measures."

The Keener sand is generally separated from the underlying Big Injun by shale and is closely overlain by the Big lime. It supports a few oil wells in the Chaseville pool but is far less productive than in the Woodsfield quadrangle, to the east, where it is the principal sand in a number of oil fields.

The Big lime is apparently missing at Chaseville but is recorded in a well recently completed near Sarahsville. Where present it ranges in thickness from a few feet to nearly 100 feet. Its absence in places is attributed to erosion which took place in Carboniferous time subsequent to the deposition of the limestone, and the uneven upper surface thus produced is evident in numerous outcrops in central and southern Ohio. The Big lime is of little value as a source of oil and gas in this area, only small quantities of either having been found in a few wells in the southeastern part of the quadrangle. Farther east at Lewisville and several other localities in Monroe County and southern Belmont County it has yielded large quantities of oil and gas. The oil occurs in layers of quartz sand which are interbedded with shaly limestone.

Several small pools of oil have been found in comparatively shallow sands in the southwestern part of the Summerfield quadrangle. Among these are sands known as the Second Cow Run, Macksburg 500-foot, Peeker, and Buell Run. Of these the most productive is probably the Buell Run. Their positions are represented in the diagram (fig. 15). Below is given a section of a well in the Buell Run sand at Low Gap, Enoch Township. From the position of the Buell Run sand it evidently lies between the Cambridge limestone and the Mahoning sandstone of the general section (fig. 14, p. 221) and is probably the Buffalo sandstone of geologists.

Log of well No. 599 (No. 4 on E. W. Wickham farm), sec. 33, Enoch Township.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Coal, Mapletown (Meigs Creek)	5	25-30	Buell Run sand	42	363-418
Red rock	105	200-305	Pay sand (oil)		418
Lime with gas (140-foot sand)		365			

The Mahoning sandstone is saturated with oil at many points near Senecaville and Lore City, and this oil is even so plentiful as to be a nuisance in some of the mines in the underlying Upper Freeport coal. It is interesting to note that some of the shallow sands support valuable oil wells at points less than 3 miles from their outcrops. Several wells near Britton station, a little beyond the southwest edge of the quadrangle, have for more than 40 years yielded oil from a sand that is probably the Buell Run. The depth of these wells is less than 100 feet, and the productive sand may be seen in outcrop a few miles north of the town of Caldwell.

STRUCTURE.

PREVAILING DIP.

The prevailing direction of slope or dip of the rocks in eastern Ohio is southeastward. The region forms the west side of a broad, shallow basin which constitutes the Appalachian coal field. The slopes of this basin are far from uniform and are traversed by numerous minor wrinkles that form anticlines and synclines. These are very insignificant when the basin is considered as a whole, but their influence in the accumulation of petroleum and natural gas has long been known, and for this reason accurate mapping of them is of importance to the oil operator.

PREPARATION OF STRUCTURAL MAP.

There are several methods of preparing structural maps of oil sands. Where an area has been extensively drilled and the sands recorded are easily recognizable, it is necessary only to determine the elevations of a large number of well heads from which, if the depth of the oil sand beneath each well head is known, the lay or attitude of the sand can be determined. Another method, employed in this investigation, is to obtain a large number of elevations on some persistent outcropping stratum, such as a coal or limestone. The region under discussion is favored with a number of excellent key beds, which can be used together for this purpose. The intervals between the several beds do not vary greatly from place to place, and all lie nearly parallel to the shallow oil sands.

In preparing the map of the Berea sand that accompanies this report elevations were determined on about 1,000 outcrops. The instrument used was the Gale telescopic alidade, and bench marks of the United States Geological Survey were used as starting points for the traverses. The resulting elevations of the several key beds were then reduced to one datum, the Pittsburgh coal, by the addition or subtraction of the appropriate interval for each bed. With the elevation of the Pittsburgh coal thus determined throughout the area the position of the upper surface of the Berea sand at each point was calculated. Unfortunately, the undulations and flexures of the Berea sand do not exactly coincide with those of the Pittsburgh coal and other strata near the surface, and this discrepancy necessitates a correction. The refinement with which this correction can be made depends upon the number of well records available. The total variation in the Pittsburgh-Berea interval for the entire Summerfield quadrangle is about 80 feet. The change is not constant in any one direction and varies rather abruptly over small areas, and for this reason the correction can be applied with precision only in areas where many well records are available. In some portions of the quadrangle the wells are several miles apart, and it is probable that between these wells many local variations in the interval exist for which no correction can at present be made. The interval, as shown in all wells of which correct records are obtained, is recorded on a drawing known as the convergence sheet, which is described in an earlier report of the Survey.[1] The drawing indicates the amount to be subtracted from each elevation of the key bed (Pittsburgh coal) in order to determine the position of the Berea at any point in the area. This amount in the Summerfield quadrangle is greater than the elevation of the Pittsburgh coal, showing the Berea to be considerably below sea level. In order to avoid using the minus sign in numbering the contours of the oil sand, 2,000 feet is added to each elevation of the key bed. This is equivalent to assuming a datum plane 2,000 feet below sea level for the map of the oil sand. After subtracting from each elevation of the key bed plus 2,000 feet the appropriate number, as shown by the convergence sheet, contour lines connecting points of equal elevation are drawn at 10-foot intervals. The resulting contour map, a representation of the lay or attitude of the upper surface of the Berea sand, is given on Plate XXII. On this map are shown all wells drilled up to the date of completion of the report. The locations of many coal test holes are also represented. All wells drilled to the Berea are represented in red. Wells drilled to shallower sands are represented in black, the appropriate abbreviation being used for the sand where known.

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[1] Griswold, W. T., and Munn, M. J., Geology of oil and gas fields in Steubenville, Burgettstown, and Claysville quadrangles, Ohio, West Virginia, and Pennsylvania; U. S. Geol. Survey Bull. 318, pp. 23-24, 99-113, 1907.

SALIENT STRUCTURAL FEATURES.

The structural contour map shows the Berea sand to lie at 1,690 feet above the assumed datum plane, or 310 feet below sea level, in the northwest corner of the area and at 1,220 feet (780 feet below sea level) in the southeast corner. This indicates a drop of 470 feet southeastward across the quadrangle. From the map it will be seen that the dip is not uniform in direction or magnitude, there being places where the rocks lie nearly flat for a mile and abruptly drop 50 feet or more in the succeeding mile, thus producing terrace-like structures. The general southeastward direction of dip is varied by minor flexures that extend across the faces of the terraces, producing downfolded embayments, which alternate with promontory-like benches, such as those 2 miles southwest of the village of Summerfield.

The principal anticlinal fold of the area extends through Chaseville in a northeasterly direction. This fold is bordered on the northwest by a shallow synclinal depression and on the southeast by a comparatively steep slope for a distance of about 2 miles. In the Chaseville oil and gas field it assumes the form of a dome, but toward the northeast it becomes less prominent. Another anticlinal fold extends southward from Quaker City to the vicinity of Summerfield and is paralleled on the west by a synclinal trough. East of Quaker City, at the edge of the quadrangle, is a shallow syncline, succeeded in turn by another anticline along which lies the Barnesville oil and gas field. The major anticlinal and synclinal folds are varied by numerous minor cross flexures, which produce the anticlinal "noses" and embayments already described.

RELATION OF STRUCTURE TO ACCUMULATION OF OIL AND GAS.

The occurrence of oil and gas pools along the crests or slopes of anticlines has been demonstrated at so many places during the 40 years since the introduction of the anticlinal theory that no one can fail to recognize the importance of these structures in oil accumulation. An excellent illustration is furnished in the Chaseville oil and gas field, in the western part of the Summerfield quadrangle, where the gas occupies the high portion of the anticlinal dome and is flanked by an oil-producing belt a little lower on the slope. The conditions there indicate a fairly open-textured sand, which permitted the circulation of water currents. It is conceivable that the oil particles were gathered from the steep slopes to the southeast and carried upward and united into the body of oil along the narrow terrace indicated by the contours. The Berea oil sand is regarded by the writer as probably saturated with salt water throughout the area, and while the oil and gas particles are in circulation they are buoyed up by the water and tend to accumulate near the crests of arches. Thus it would appear that Chaseville furnishes an example of the simplest application of the anticlinal theory, where the oil sand is fairly open-textured, saturated with salt water, and bent into an anticlinal arch. A study of other oil and gas pools indicates that this combination of ideal conditions is not usual and that there are numerous modifying influences which must be considered. For example, well-defined anticlines are far from plentiful in southeastern Ohio, and more commonly the arches are merely promontory-like "noses," such as that in the extreme southeast corner of the Summerfield quadrangle. Another modifying factor is the condition of the sand. The Berea is not made up of a single sheet of open-textured sand readily permeable by water but consists for the most part of hard, compact, fine-textured "lime" or "shells" with localized beds of "pay" sand of lenticular shape and only a few feet thick. Such is the condition in the Summerfield gas pool, where the pay sand is compact and of variable thickness, and the pool is bordered on the south by several "dry holes," in which "no sand" is reported by the drillers. The limited extent of the lenticular pay sand has prevented the migration of the gas up the slope to a location structurally more promising, and it is retained on the flank of a shallow synclinal embayment.

The quantity of salt water yielded by wells in this field, though very slight, is not believed by the writer to indicate incomplete saturation, but rather to show that the rock is so fine in texture that it holds the water, even though it rises in the rock as the gas is exhausted.

The water conditions in the Big Injun and other shallow sands are decidedly different from those in the Berea. In many wells the water flows from the sand into the hole and rises within a few hundred feet of the surface, and the flow is so great that it can not be reduced by bailing. Oil wells found in these sands are commonly brought to an untimely end by being "drowned out."

SEARCH FOR NEW POOLS.

The study of the Berea oil sand in the Summerfield and other quadrangles of southeastern Ohio forces the conclusion that conditions of oil accumulation are controlled by so many intangible factors that no one can with certainty predict the location of oil pools in advance of drilling. The structural map, even though made most carefully, may not accurately represent the surface of the Berea sand in a country that has been little drilled, owing to the variable distance of the Berea below beds that lie near the surface. Furthermore, it does not follow that oil or gas will be found in even the location structurally most favorable, for the reason that the accumulation in pools is controlled by many factors, such as the trend, extent, and texture of a lens of pay sand and its degree of saturation with salt water. It is noteworthy, however, that even in a sand such as the Berea most of the pools closely follow the strike of the rock or in other words extend parallel to the structural contours. The utility of the structural map in predicting the extension of pools after the first successful wildcat well is drilled is thus at once evident. In addition the driller will be able to determine in which direction the next location should be made in order to find the oil sand at a higher point after a well showing oil and considerable salt water has been drilled.

In selecting territory favorable for prospecting in the Berea no points in the south third of the quadrangle can be regarded as promising on account of the poor condition of that sand as reported in numerous test holes. This is especially true in the vicinity of Sarahsville and the region south of Summerfield. It is probable that many gas wells will yet be drilled in the Summerfield pool, especially at the northeast end, but the finding of any considerable accumulation of oil seems improbable.

In the vicinity of Kennonsburg there is a large untested area. It lies along the southeast slope of the Chaseville anticline, and to the east the rocks drop about 100 feet in a distance of 2 miles. The terrace on the west side of the village and also to the northeast, along the 1,500-foot contour, would seem favorable territory for prospecting. There is also a possibility of finding oil or gas along the crest of the axis 3 miles due east of Senecaville. Territory almost equally favorable lies a little east of the syncline in Beaver Township, along the valley of Beaver Creek 1 to 2 miles west of Batesville.

Extensions of the Chaseville oil pool along the strike will probably be made. The chances of finding a valuable accumulation of oil on the northwest side of the anticlinal axis seem slight, for the reason that the anticline is paralleled by a shallow syncline that furnishes only a small gathering area from which the oil could be collected.

Since the preparation of this report a gas well in the Berea sand has been drilled 1½ miles northeast of Mount Ephraim. Another discovery is a gas well near Sarahsville, reported to be in the Gordon sand. This is of interest, but probably not of great importance, as this is the second place in eastern Ohio where gas has been obtained from the Gordon. The other place is at Macksburg, in Washington County.

A structural map prepared for the shallow sands shows that the small pools in the southern part of the quadrangle are intimately related to troughlike folds, although this is not so evident on the map of the Berea sand. This map can not be included here but will appear in a report now in preparation, in which detailed attention will be given to the oil fields and also to coal and other mineral resources in the Summerfield quadrangle.

QUALITY OF THE OIL.

The oils of this region are shown by analyses to be of the best Pennsylvania grade, ranging from 36° to 50° Baumé in gravity and from light amber to dark green in color. Asphalt and sulphur are lacking, and the percentage of paraffin ranges from 2.5 to more than 10. A number of analyses have been published by the United States Geological Survey.[1]

PUBLICATIONS.

The United States Geological Survey has published the following bulletins concerning oil and gas fields in eastern Ohio and adjacent parts of West Virginia and Pennsylvania:

198. The Berea grit sand in the Cadiz quadrangle, Ohio, by W. T. Griswold. 1902. 43 pp., 1 pl.
286. Economic geology of the Beaver quadrangle (southern Beaver and northern Allegheny counties), Pa., by L. H. Woolsey. 1906. 132 pp., 8 pls.
318. Geology of oil and gas fields in Steubenville, Burgettstown, and Claysville quadrangles, Ohio, West Virginia, and Pennsylvania, by W. T. Griswold and M. J. Munn. 1907. 196 pp., 13 pls.
346. Structure of the Berea oil sand in the Flushing quadrangle, Harrison, Belmont, and Guernsey counties, Ohio, by W. T. Griswold. 1908. 30 pp., 2 pls.
456. Oil and gas fields of the Carnegie quadrangle, Pennsylvania, by M. J. Munn. 1911. 99 pp., 5 pls.

541-A. Oil and gas in the northern part of the Cadiz quadrangle, Ohio, by D. D Condit. 1913. 9 pp., 1 pl.

621-H. Anticlines in the Clinton sand near Wooster, Wayne County, Ohio, by C. A. Bonine. 1915. 11 pp., 1 pl.

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[1] U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 1212-1217, 1914.

STRUCTURE OF THE BEREA OIL SAND IN THE WOODSFIELD QUADRANGLE, BELMONT, MONROE, NOBLE, AND GUERNSEY COUNTIES, OHIO.

By D. Dale Condit.

INTRODUCTION.

The information set forth in this report is the result of four months of field work during the season of 1914, during which the writer was assisted by R. V. A. Mills and Frank Reeves. A detailed geologic investigation was made of the mineral resources of the Woodsfield quadrangle and of the Summerfield quadrangle, adjoining it on the west. In this report are given briefly the more important features pertaining to the geology of the oil and gas fields of the Woodsfield quadrangle. A similar report has been prepared for the Summerfield quadrangle. These preliminary papers are to be followed by a bulletin in which the geology of the oil and gas fields will be considered in greater detail and in which attention will also be given to coals and other mineral resources.

It is desired to express the thanks of the field party to the residents of the region for many courtesies, and to the oil drillers and operators for their cooperation. Special thanks are due to the officials of the Carter Oil Co. and the Pure Oil Co., to Mr. J. W. Hardwick, of the Ohio Fuel Supply Co., and to others who furnished maps and well records.

GEOGRAPHY.

The Woodsfield quadrangle is situated in southeastern Ohio and includes parts of Belmont, Monroe, Noble, and Guernsey counties. The location and extent of the area is represented in figure 13, which also shows other areas in southeastern Ohio and adjacent parts of Pennsylvania and West Virginia for which structural maps of the oil sands have been prepared. The Woodsfield quadrangle is adjoined on the north by the Flushing quadrangle, the structure of which is described in Bulletin 346 of the United States Geological Survey.

The principal towns in the area are Barnesville, in the northwest corner of the quadrangle, on the Baltimore & Ohio Railroad, and

Woodsfield, near the south edge of the quadrangle, on the Ohio River & Western Railroad, a narrow-gage line which follows a devious route from Bellaire, on Ohio River, westward to Zanesville. The population of Woodsfield, according to the census for 1910, was 2,502, and that of Barnesville 4,233. Smaller villages are Beallsville, Jerusalem, Ozark, and Lewisville, which are along the narrow-gage railroad, and Miltonsburg, Malaga, Somerton, and Temperanceville, which are 3 to 6 miles from any railroad. All but the southwest quarter of the quadrangle is underlain by the Pittsburgh coal in workable thickness, and the time is not remote when this coal will be the basis for an extensive mining industry. The only shipping mine now in operation is at Baileys Mills, on the Baltimore & Ohio Railroad, 3 miles southwest of Barnesville.

The highlands dividing eastward-flowing tributaries of Ohio River from westward-flowing branches of Tuscarawas River extend in a north-south direction across the western part of the quadrangle. Captina and Sunfish creeks, the principal streams, occupy deep, narrow valleys equal in bold ruggedness to any others in the State. The local relief from the valley floor of Sunfish Creek to neighboring hilltops ranges from 400 to 500 feet, and the maximum relief for the entire quadrangle is about 700 feet. The greatest altitude is 1,420 feet, on a hilltop 1½ miles northwest of Miltonsburg, and the least is found along the valley of Sunfish Creek, being only slightly more than 700 feet near the southeast corner of the area.

GEOLOGY.

STRATIGRAPHY.

The rocks at the surface in the Woodsfield quadrangle are of Pennsylvanian ("Coal Measures") and Permian age and include in ascending order the Conemaugh, Monongahela, and Washington formations as classified by geologists. The dip or slope of the beds is in general southeastward; therefore higher and higher strata are crossed when one travels in that direction. The direction and degree of the inclination of the strata have an important bearing on the location of oil pools, and these features are described under the heading "Structure" (pp. 243–247).

GENERAL SECTION.

The stratigraphy of eastern Ohio has been discussed in previous reports, and only a brief outline is needed here. The several formations represented, with their approximate thicknesses, are listed below. The classification given for the Mississippian rocks is the one introduced by Ohio geologists for these beds where they crop out in the central part of the State.

General section of formations in eastern Ohio.

	Feet.
Permian series:	
Washington formation ("Upper Barren")	400±
Pennsylvanian series ("Coal Measures"):	
Monongahela formation ("Upper Productive")	255–275
Conemaugh formation ("Lower Barren")	460–475
Allegheny formation ("Lower Productive")	250–265
Pottsville formation	155–170
Unconformity.	
Mississippian series:	
Maxville limestone (Big lime)	0–110
Unconformity.	
Logan formation (includes Keener sand)	600–700
Black Hand formation (includes Big Injun sand)	
Cuyahoga shale	
Sunbury shale	
Berea sandstone	
Bedford shale	

The Mississippian formations constitute the great oil-bearing rocks of southeastern Ohio and include the Berea, Big Injun, Keener, and Big lime sands, all of which are productive in the Woodsfield quadrangle. In outcrops some 80 miles to the west and northwest the same beds are quarried for building stone. Below the Berea is a great thickness of shale, the bottom of which has never been penetrated by the drill within the Woodsfield quadrangle. The Clinton sand, which yields much oil and gas in central and northeastern Ohio, if present in this region lies more than 4,000 feet below the Berea sand.

The Maxville limestone, known among oil drillers as the Big lime, varies considerably in thickness and is apparently missing in some parts of the Woodsfield quadrangle. This is to be expected, for the limestone is variable where seen in outcrop. It is overlain unconformably by sandstone, which forms an undulating contact and locally extends across the limestone, entirely replacing it.

The Pennsylvanian or "Coal Measures" rocks are made up largely of shale, clay, and sandstone, with numerous beds of coal and limestone. Several of the sandstones are oil bearing. The Pottsville and Allegheny formations and all but the upper third of the Conemaugh formation are below the surface throughout the quadrangle. The Allegheny is the great coal-bearing formation in the northern Appalachian coal basin. In Ohio, though only a little more than 250 feet thick, it includes a number of coal and clay beds of great economic importance. The Conemaugh is appropriately called the "Lower Barren," for it contains no coals of great value and also lacks important beds of limestone and clay. It consists for the most part of shale and reddish-brown clay, with lenses of sandstone. The Monongahela formation contains the Pittsburgh, Meigs Creek, and other valuable coal beds and important beds of limestone, together with sandy shale, clay, and nonpersistent beds of sandstone.

The Washington formation of the Permian series lacks valuable beds of coal and is characterized by nonpersistent sandstone members, with shale and clay commonly of reddish-brown color. The few coals and thin limestone beds of the formation are found near the base.

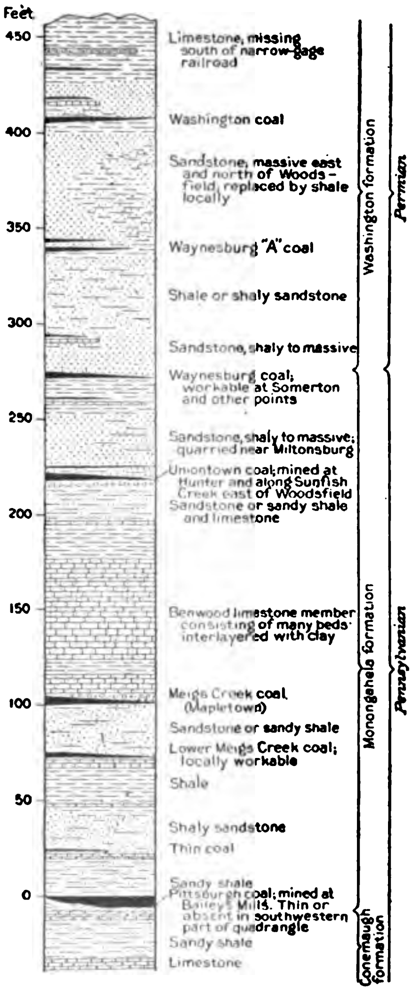
Feet
450
400
350
300
250
200
150
100
50
0
Limestone, missing south of narrow-gage railroad
Washington coal
Sandstone, massive east and north of Woodsfield, replaced by shale locally
Waynesburg "A" coal
Shale or shaly sandstone
Sandstone, shaly to massive
Waynesburg coal; workable at Somerton and other points
Sandstone, shaly to massive; quarried near Miltonsburg
Uniontown coal; mined at Hunter and along Sunfish Creek east of Woodsfield
Sandstone or sandy shale and limestone
Benwood limestone member consisting of many beds interlayered with clay
Meigs Creek coal (Mapletown)
Sandstone or sandy shale
Lower Meigs Creek coal; locally workable
Shale
Shaly sandstone
Thin coal
Sandy shale
Pittsburgh coal; mined at Bailey's Mills. Thin or absent in southwestern part of quadrangle
Sandy shale
Limestone
Washington formation
Permian
Monongahela formation
Pennsylvanian
Conemaugh formation

FIGURE 16.—Generalized section of rocks exposed in the Woodsfield quadrangle, Ohio.

ROCKS EXPOSED.

The thickness of the beds exposed within the Woodsfield quadrangle is about 800 feet. These beds are in part represented in figure 16. The exposures lowest in the geologic column are found along Leatherwood Creek, southwest of Barnesville, and the highest are in the ridges east of Woodsfield. The more important beds will be described in turn, beginning with the lowest.

The Pittsburgh coal crops out along the valleys west and southwest of Barnesville and also at Temperanceville. Farther east it is 100 feet or more below the surface throughout the quadrangle. It is recorded in nearly all oil wells and has also been tested by core drilling and is known to be present in workable thickness over the greater part of the area. The chief exception is the southwest corner, the limit of the workable coal being, roughly, a line drawn from Temperanceville to Miltonsburg, thence to Lewisville or possibly to Woodsfield. The rocks at the Pittsburgh horizon are exposed along the valleys of Seneca and Paynes forks south of Temperanceville, but the coal is too thin to be of value.

The Pittsburgh coal is correctly identified by oil men in drilling operations throughout the region, and its position with reference to higher strata is so well established by dozens of hillside measurements and by core-drill and oil-well records that it is chosen as the most convenient key bed for mapping the structure of quadrangles in this part of Ohio.

The Meigs Creek (Mapletown) coal lies 97 to 120 feet above the Pittsburgh bed. The larger interval is unusual and was found only in the region west of Barnesville. Another coal, the Lower Meigs Creek, is found in numerous places in the quadrangle 20 to 35 feet below the Meigs Creek proper. The two coals are commonly separated by massive sandstone. Typical exposures of the lower coal may be seen along Seneca Fork of Wills Creek, where it is mined for local use. The Meigs Creek coal lies near the valley floor of Captina Creek for miles eastward from Barnesville, and at the east edge of the quadrangle it is a few feet below the bed of the creek. In Adams Township the same coal is a few feet beneath the valley floor of Sunfish Creek and no outcrops were discovered.

From 100 to 120 feet above the Meigs Creek coal is the Uniontown coal, which is useful as a structural key on account of its extensive outcrop. Its value for this purpose is somewhat lessened, however, because the coal is in places divided into two beds separated by about 10 feet of shale. The Uniontown coal is mined along Sunfish Creek east of Woodsfield and also along Jakes Run and Bend Fork, tributaries of Captina Creek.

Three more beds that are noteworthy on account of their utility in structural mapping appear above the Uniontown coal, namely, the Waynesburg coal, at the top of the Monongahela formation, and the Waynesburg "A" and Washington coals, in the Washington formation. The first two are accompanied by thinner, less persistent beds, which necessitate careful study to avoid confusion. The Washington coal is an excellent key bed, being persistent with a thickness of 1 to 2 feet throughout the area, but it also is accompanied by other coal beds, one 10 feet higher and another 26 feet higher. The Washington coal is about 350 feet above the Pittsburgh in Goshen Township, in the northeast corner of the quadrangle. Toward the south the interval between the two coals gradually increases to about 400 feet at the Belmont-Monroe county line and to 420 feet at the south edge of the quadrangle.

About 40 feet above the Washington coal is a bed of limestone which was used as a guide in mapping in Belmont County. To the south, in Monroe County, this limestone is lacking, and in its place is greenish-gray brittle granular clay.

ROCKS PENETRATED BY THE DRILL.

Below the surface are about 2,000 feet of rocks which are fairly well known through evidence furnished by the drill. The Berea sand, the chief objective in the search for oil, lies 1,400 to 2,000 feet below the surface, and beneath it is an unknown thickness of shale practically devoid of oil sands, in southeastern Ohio. The general sequence of the oil sands, their names applied by oil men, and positions with reference to the Pittsburgh coal are represented in figure 17. The subjoined well records further illustrate the character of the rocks below the surface:

Log of well No. 90 on John Kemp farm, sec. 13, Goshen Township, Belmont County.

[Well nonproductive.]

	Thickness.	Depth.
	Feet.	*Feet.*
Coal (Waynesburg)	4	144-148
Coal (Meigs Creek)	3	297-300
Coal (Lower Meigs Creek)	3	325-328
Coal (Pittsburgh)	3	393-396
Second Cow Run sand	85	860-945
First salt sand	60	1,030-1,090
Sand	40	1,110-1,150
Second salt sand	45	1,205-1,250
Maxton sand	49	1,285-1,334
Big lime	51	1,334-1,385
Keener sand	37	1,385-1,422
Big Injun sand	173	1,422-1,595
Welsh stray sand	154	1,750-1,904
Berea sand	20	1,957-1,977
Total depth		2,006

Log of well No. 372 (No. 1 on Martha Mobley farm), sec. 31, Adams Township, Monroe County.

[Gas well.]

	Thickness.	Depth.
	Feet.	*Feet.*
Conductor		0- 9
Coal	3	167- 170
Coal (Pittsburgh)	4	504- 508
Red rock	100	600- 700
Lime	50	700- 750
Red rock	75	750- 825
Slate	45	825- 870
First Cow Run sand	20	870- 890
Second Cow Run sand	185	950-1,135
"Slate"	115	1,135-1,250
First salt sand (water at 1,280 feet)	60	1,250-1,310
Lime	10	1,310-1,320
Second salt sand (water, 1½ barrels an hour, at 1,335 feet)	65	1,320-1,385
"Slate"	15	1,385-1,400
Maxton sand	50	1,400-1,450
"Slate"	30	1,450-1,480
Big lime		1,480
Keener sand (scum of oil at 1,586 feet; water rising 200 feet in 3 hours at 1,591 feet; water, 1 barrel an hour, at 1,615 feet)	33	1,582-1,615
"Slate"	10	1,615-1,625
Big Injun sand (little dark oil and gas at 1,665 feet)	175	1,625-1,800
"Slate" and lime	115	1,800-1,915
Welsh sand, limy	75	1,915
Berea sand (gas at 2,163 feet)	10	2,160-2,170
Total depth		2,179

Log of well No. 457, on Peter Ulrich farm, sec. 9, Malaga Township, Monroe County.

[Well nonproductive.]

	Thickness.	Depth.
	Feet.	*Feet.*
Coal (Waynesburg)		195
Coal (Meigs Creek)		335
Coal (Pittsburgh)		425
Cave		500
Cow Run sand		860
Salt sand	140	1,045–1,185
Maxton sand	100	1,250–1,350
Big lime (fine sand, poor, at 1,380 feet)	55	1,370–1,425
Keener sand (15 feet of white sand)	44	1,451–1,495
Big Injun sand	105	1,530–1,635
Shale break	10	1,635–1,645
Squaw sand	60	1,645–1,705
Berea, poor sand, top at		2,026

Many of the sandstone beds recorded in well logs are characterized by lack of persistence, and all are far from uniform in thickness, texture, and appearance from place to place. The uncertainty of the "Coal Measures" sandstones is evident when any prominent bed is followed for a short distance along its outcrop. Almost without exception it will be found to grade laterally into shale, and in many places the change is rather abrupt. On the other hand, two or more sandstone beds separated by shale "breaks" may locally combine into one thick bed of sandstone. A comparison of well records within the Woodsfield quadrangle shows that there is a lack of uniformity in the application of names to the several sands. For instance, the name Cow Run is applied to beds ranging from 340 to more than 500 feet below the Pittsburgh coal at different localities in the Woodsfield quadrangle, whereas the true position of the First Cow Run sand in Monroe County is 310 to 320 feet below the Pittsburgh coal.

OIL AND GAS SANDS.

General occurrence.—The search for oil and gas in the Woodsfield quadrangle has led to more extensive drilling than has been done in almost any other portion of southeastern Ohio. About 1,950 wells have been drilled, two-thirds of which are in the south half of the quadrangle. The area is in that favored portion of Ohio where the driller can hope to find oil in any one of a number of sands ranging in position from about 300 to 1,600 feet below the Pittsburgh coal. The most noteworthy productive sands, named in descending order, are the so-called Cow Run, Big lime, Keener, Big Injun, and Berea. The sequence of these sands and their relations to other beds are shown in the generalized section (fig. 17). The pools in which these various sands are productive are represented on Plates XXIV and XXV (in pocket). The Berea sand is an important source of oil and gas at three localities, designated on the maps the Barnesville, Temperanceville, and Woodsfield Berea grit pools, and in addition yields considerable gas in a recently discovered pool, the Schriver, southeast of Beallsville, along the east margin of the quadrangle. The Big Injun sand yields oil and gas at numerous points in the southwestern part of the area, the most productive pool being at Lewisville, with scattered wells to the northeast for several miles. The Keener sand probably ranks first as a source of oil in the area. It is productive at Malaga, Miltonsburg, Monroefield, and Lewisville and northeastward from Lewisville in an almost continuous belt for 6 miles. The Big lime sand is likewise of great importance, and its productive areas are coextensive with several of the Keener pools. In fact, there are many wells in which both sands are productive and the same wells may also derive oil from the Big Injun sand. Some of the more productive pools in the Big lime are at Newcastle and on Brushy Creek in Belmont County, and at Jerusalem, Ozark, Lewisville, and several intermediate points, in Monroe County. A still shallower sand called by oil men the Cow Run is productive in the vicinity of Beallsville. This sand is about 350 feet below the Pittsburgh coal, and its position suggests correlation with the Buell Run sand of Noble County rather than with the Second Cow Run sand.

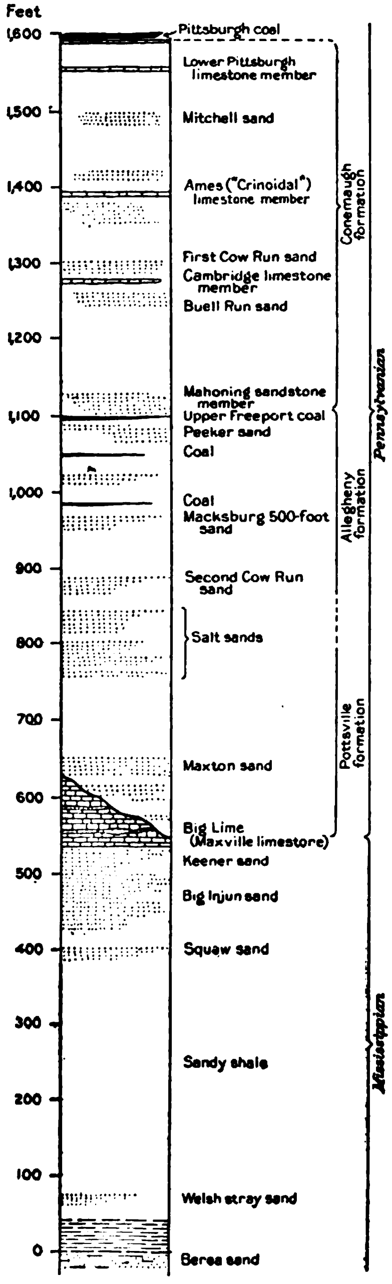

FIGURE 17.—Generalized section showing oil sands and accompanying beds in Woodsfield quadrangle, Ohio.

Names are applied by oil men to nearly every sand penetrated in drilling, and these are represented in figure 17, but the oil men are far from consistent in their use of several of the names applied in the section. Some of the terms in use are derived from localities in Washington County, Ohio; others are obtained from oil pools in West Virginia. As a result there is some confusion in the correlation of beds, and a single sand may be designated by several names in different localities. The skill of the drillers in correctly identifying beds, however, is remarkable when it is borne in mind that none of the sands maintain a uniform thickness over any considerable area, and not uncommonly several beds are combined into one great mass of sandstone. Elsewhere the sands are broken into a series of alternating beds of shale and sandstone, or are even entirely missing and only "shells" are recorded in their places.

Berea sand.—The Berea sand is one of the most important sources of oil and gas in southeastern Ohio and is the deepest oil sand that can be explored with a hope of profit in the Woodsfield quadrangle. It lies 1,550 to 1,660 feet below the Pittsburgh coal, the interval between it and beds near the surface varying considerably from place to place. For this reason a map showing accurately the lay of the Pittsburgh coal is not directly applicable to the Berea sand, and a correction for the variation in interval is required.

The thickness of the Berea is generally reported at 20 to 30 feet, but a few records show less than 10 feet. There is great variation in texture from place to place, and locally the sand is so fine textured and shaly that it is barely recognizable, and its position would not be detected were it not for the black shale which immediately overlies the Berea in Ohio. In the midst of the Berea are lenticular beds of coarser sand which serve as reservoirs for the oil and gas and hence are called the "pay sands." These are not persistent and vary in thickness. The color is generally white, and the grains of fairly uniform fineness, with no pebbles. The thickness of the "pay" sand in the several oil pools ranges from 4 to 15 feet, and in position it lies a few inches to more than 14 feet below the top of the Berea.

Big Injun sand.—The usual thickness of the Big Injun sand is about 100 feet, but at some places it is 175 feet or more and at others 50 feet or even less. In the southwestern portion of the Woodsfield quadrangle the Big Injun sand, where productive, is generally 40 to 60 feet thick. The sand is coarser textured than the Berea and contains pebble layers which are oil bearing and constitute the pay sands. Three or more of these may be found in a single well. The Big Injun is generally water bearing, and the life of the wells is commonly cut short by an inflow of salt water. Not infrequently the Big Injun sand is found separated into a number of beds interlayered with shale. There are great variations in thickness and shaly character in short distances. In fact, the Big Injun resembles sandstones of the "Coal Measures" in its diversity from place to place.

Keener sand.—The Keener sand is separated from the Big Injun by shale and is likewise overlain by shale, which separates it from the Big lime. The usual thickness of the Keener is about 25 to 35 feet, but in the vicinity of Woodsfield a few well records show as much as 60 feet. It is made up of alternating beds of coarse and fine grained sand varying in color from white to dark. The coarser beds yield great quantities of water, which is a menace to oil wells.

Several layers of sand in the Keener may be found oil bearing, and it is of interest to note that the oils from the different pay sands have not the same properties. In the pools east of Malaga the oils vary in viscosity, a portion being so thick that "steaming" is required in order to facilitate the flow through pipes, even in the summer months, whereas another oil from the Keener sand in the same vicinity flows readily without "steaming."

The initial production of many of the wells in the Keener sand has been 100 barrels a day and in a few is reported at more than 500 barrels. The life of the wells is as a rule shorter than that of wells in the Berea sand.

Big lime sand.—The Big lime, as its name implies, is made up largely of limestone in many beds alternating with sandy layers in which the oil and gas are collected. The thickness of the Big lime is reported to be 100 feet in a few places, but 30 to 60 feet is more common. In general the thickness diminishes toward the northwest, and in parts of the Summerfield quadrangle, adjoining the Woodsfield on the west, the Big lime is missing. It shows abrupt variations in thickness and character from place to place, as is illustrated by records of wells in the vicinity of Lewisville. On the Cooper farm, 3 miles northeast of the village, the Big lime is reported 100 feet thick with great quantities of salt water 31 feet below the top, whereas on the Buchanan farm, 1½ miles east of Lewisville, the Big lime is about 25 feet thick.

The pay sand is reported to consist of moderately coarse sand in layers 5 to 15 feet thick. A number of wells in the Big lime sand have had an initial production of 100 barrels a day, and 500 barrels is claimed for a few, but in most pools the best wells start at 25 barrels or less.

Other oil sands.—Above the Big lime are a number of oil-bearing sands which have been prospected rather extensively by the driller with moderately favorable results. The various sands have received names, which are shown in figure 17. The Maxton sand, closely overlying the Big lime, is productive at a few points east of Lewisville. Gas is found in the Salt sands, and oil in a sand reported to be the Cow Run. The production along the railroad northeast of Beallsville and also about 2 miles southeast of that village is credited to the

Cow Run sand, although its position, 350 feet below the Pittsburgh coal, suggests that it may possibly be equivalent to the Buell Run sand, which is productive in the region south of Summerfield, Noble County. The position of the First Cow Run sand where present in the Woodsfield quadrangle should be 280 to 310 feet below the Pittsburgh coal.

The oil from the Cow Run sand at Beallsville has a beautiful amber color. The best wells produced 20 to 25 barrels a day when first drilled, and a number after being pumped for more than 10 years still yield three to five barrels a day.

STRUCTURE.

The prevailing direction of slope or dip of the rocks in eastern Ohio is southeastward. The region forms the west side of a broad, shallow basin which constitutes the Appalachian coal field. The slopes of this basin are far from uniform and are traversed by numerous minor wrinkles which form anticlines and synclines. These are very insignificant when the basin is considered as a whole, but because of their influence in the accumulation of petroleum and natural gas accurate mapping of them is of importance to the oil operator.

PREPARATION OF STRUCTURAL MAP.

The methods of preparing structural maps of oil sands are outlined in the report on the Summerfield quadrangle (pp. 227–228). In preparing the contour map of the Berea sand which accompanies this report, elevations were determined on about 850 outcrops of several key beds and were then reduced to one datum, the Pittsburgh coal, by the addition or subtraction of the appropriate interval for each bed. With the elevation of the Pittsburgh coal thus determined throughout the area the position of the upper surface of the Berea sand at each point was calculated. Unfortunately, the undulations and flexures of the Berea sand do not exactly coincide with those of the Pittsburgh coal and other strata near the surface, and this necessitates a correction. The refinement with which this correction can be made depends upon the number of well records available. The Pittsburgh–Berea interval shows a total variation in the entire Woodsfield quadrangle of about 100 feet, being 1,550 feet in the northeastern part of the quadrangle and 1,650 feet in the southern part, east of Woodsfield. The change is not constant in any one direction and varies rather abruptly over small areas, and for this reason the correction can be applied with precision only in areas where many well records are available. In some portions of the quadrangle the wells are a mile or more apart, and it is probable that between these wells local variations in the interval exist for which no correction can be made. As the Berea sand lies considerably below sea level, 2,000 feet is added to each elevation of the key bed in order to avoid using the minus sign in numbering the contours of the oil sand. This is equivalent to assuming a datum plane 2,000 feet below sea level for the map of the oil sand. The contour map (Pl. XXIV) represents the lay or attitude of the upper surface of the Berea sand and shows all wells drilled up to the completion of the report. The locations of many coal test holes are also indicated. All wells drilled to the Berea are represented in red. Wells drilled to shallower sands are represented in black, the appropriate abbreviation being used for the sand where known.

SALIENT STRUCTURAL FEATURES.

The structural contour map shows the Berea sand to lie at 1,500 feet above the assumed datum plane, or 500 feet below sea level, in the northwest corner of the area and at 940 feet (1,060 feet below sea level) in the southeast corner, indicating a drop of 560 feet southeastward across the quadrangle. From the map it will be seen that the dip is fairly uniform in direction and degree, but there are places where the rocks lie nearly flat for a mile and abruptly drop 50 feet or more in the succeeding mile, thus producing terrace-like forms such as the one at Temperanceville. The general southeastward direction of dip is varied by minor flexures that extend across the faces of the terraces, producing down-folded embayments which alternate with promontory benches, typical illustrations of which appear along the Belmont-Monroe county line 3 miles southeast of Somerton.

Well-defined anticlinal folds are far from plentiful in this region, and there are in the quadrangle only two of any prominence. One lies west of Barnesville, extending in a southwesterly direction. Along its summit is a gas field and on the east slope an oil pool. On the northwest side is a shallow synclinal depression. An irregular anticlinal fold extends southward from Temperanceville and on its east flank the strata drop abruptly into a synclinal depression near the village of Somerton. One mile east of Somerton is a small anticlinal "nose" extending southward for several miles. The town of Woodsfield is situated in a shallow structural depression, east of which is a slightly higher terrace with a gentle southeastward slope, and on this is situated in the Woodsfield Berea grit oil pool. Extending southward from this locality beyond the area represented on the map is an anticlinal arch which may be coextensive with the Jackson Ridge oil pool.

RELATION OF STRUCTURE TO ACCUMULATION OF OIL AND GAS.

The occurrence of oil and gas pools along the crests and slopes of anticlines has been demonstrated at so many places during the 40 years since the introduction of the anticlinal theory that no one can fail to recognize the importance of these structures in oil accumulation. An excellent illustration is furnished in the Barnesville oil and gas field, in the northwestern part of the Woodsfield quadrangle, where the gas occupies the high portion of the anticlinal fold and is flanked by an oil-producing belt a little lower on the slope. The well logs for this field indicate a fairly open textured sand which permitted the circulation of water currents. It is conceivable that the oil particles were gathered from the steep slopes to the southeast and gradually—perhaps with some oscillatory motion—carried upward and united into the body of oil along the narrow terrace indicated by the contours, or they may have been brought from some other direction. The Berea oil sand is probably saturated with salt water throughout the area, and the oil and gas particles, while in circulation, are buoyed up by the water and tend to accumulate near the crests of arches. Thus the Barnesville pool furnishes an example of the simplest application of the anticlinal theory, where the oil sand is fairly open textured, saturated with salt water, and arched into an anticline. A study of other oil and gas pools indicates that this combination of ideal conditions is not usual and that elsewhere numerous modifying influences have been effective. In the first place, well-defined anticlines are far from plentiful in southeastern Ohio, and more commonly the arches are merely promontory-like " noses " such as that in the extreme southwest corner of Wayne Township.

Another modifying factor is variation in porosity. The Berea is not made up of a single sheet of open and even textured sand readily permeable by water but consists for the most part of hard, compact, fine-textured " lime " or " shells " with lenticular beds of " pay " sand only a few feet thick. Such is its character in the Summerfield gas field in the adjoining quadrangle to the west. Here the pay sand is compact and of variable thickness and the pool is bordered on the south by several dry holes in which "no sand" is reported by the drillers. The limited extent of the pay sand has prevented the migration of the gas up the slope to a location structurally more favorable, and it is retained on the flank of a shallow synclinal embayment. The quantity of salt water yielded by the wells in this field, though slight, is not believed by the writer to indicate partial saturation, but rather to show that the rock is so fine in texture that it holds the water even though it rises in the rock as the gas is exhausted.

From well records gathered in various parts of eastern Ohio it is evident that the Berea sand contains more or less salt water from a point near the outcrop down the dip to a position far below sea level. Where the rocks are comparatively pervious over considerable areas and the quantity of water is not sufficient to fill all pore spaces entirely it occupies the lower portion of the sand, and there is an upper limit of saturation existing as a nearly level water table of considerable extent. Conditions of this kind are found in the northern part of the Steubenville quadrangle, where the position of the water line is about 270 feet below sea level and rises gradually northward. This water table in the Berea sand is of local extent and probably has no relation to water tables in the same sand in other areas to the west and north. The partial saturation in this area does not signify that the quantity of salt water becomes less as the oil sand is followed up the dip. On the contrary, great quantities of salt water and also some oil are derived from the Berea all the way from the Woodsfield quadrangle northwest to Wooster and beyond, where the sand is only a little below the surface. It is even possible that the amount of water is progressively greater as the Berea is followed up the dip. This is to be expected in shallow areas, where contributions from ground-water circulation would probably be received.

In the same connection it should be emphasized that in the more porous strata water and oil seem to seek the lowest level that is readily accessible and to flow into the hole when a well is drilled. But it is believed by the writer that the failure of one or both to do so does not necessarily signify that the sand is dry. The texture of the sand may be found so fine as to enable it to hold its liquid content even when there is considerable gas pressure.

The water conditions in the Big Injun, Keener, and other shallower sands differ from those in the Berea. The sands are as a rule more open textured and give off quantities of water, which not infrequently rises to the surface in a well that is being drilled. Many oil wells are ruined by an inflow of salt water, but on the other hand wells have been drilled through all these sands without encountering either oil, gas, or water.

The Monroefield pool may be cited as an area where the Keener sand yields almost no salt water. Whether this signifies only slight saturation or is to be attributed to the close texture of the sand can not be stated until more detailed study has been given to the matter. It is worthy of note that in the Malaga and Cooper oil pools, some 70 feet down the dip, many Keener wells yield great quantities of salt water.

In several oil sands in the Woodsfield quadrangle the water in one oil pool situated on an anticlinal "nose," terrace, or other structural feature is commonly found to be a hydrostatic unit entirely independent of water conditions in another pool near by, even though the sands in the two pools lie at the same horizon. The same thing is also true of overlapping sand lentils separated by shale. In some places oil and much water are found in one stratum, and gas with little or no water in another stratum 40 feet lower. It does not seem strange, therefore, that in crossing down the dip in the Woodsfield quadrangle a succession of gas and oil is found to be repeated several times within a distance of a few miles. The localization of the oil into a number of small pools rather than into one large pool is in part explained by the gentle dip, which does not favor the migration of oil, and in part by the "spotted" condition of the sand.

SEARCH FOR NEW POOLS.

The study of the Berea and other oil sands in the Woodsfield and other quadrangles of southeastern Ohio forces the conclusion that the conditions of oil accumulation are controlled by so many intangible factors that in this region no one can with certainty predict the location of oil pools in advance of drilling. The structural map, even though made most carefully, may not accurately represent the surface of the Berea sand in a country that has been little drilled, owing to the varying distance of the Berea below beds that lie near the surface. Furthermore, it does not follow that oil or gas will be found in even the structurally most favorable location, for the reason that the accumulation into pools is controlled by many factors, such as the trend, extent, and texture of a lens of pay sand and its degree of saturation with salt water. It is noteworthy, however, that even in a sand such as the Berea the pools for the most part follow closely the strike of the rock or in other words extend parallel to the structural contours. The utility of the structural map in predicting the extension of pools after the first successful wild-cat well is drilled is thus at once evident. In addition it enables the driller to determine in which direction his next location should be made in order to find the oil sand at a higher point after a well showing oil and considerable salt water has been drilled.

The search for oil and gas in the Berea sand has been so thorough that dry holes are distributed at intervals of 1 to 2 miles in the areas between the several pools in this sand. In most of these holes the condition of the sand is reported unfavorable. It seems improbable that any undiscovered large pools remain in this quadrangle. Probably the most promising area in the quadrangle for prospecting is to the east and southeast of Temperanceville. Well 67 is a small oil producer in the Berea sand, and the area around it, especially to the southeast, is suggested as most favorable and the area to the south as almost equally promising. Mention should also be made of the terrace 1 mile south of Boston, where a show of oil is reported in well 131. Farther south, along the west margin of the quadrangle, the Berea sand is commonly reported "broken" and fine textured, but here and for several miles to the west it yields gas in wells of small volume but long life.

Both the Barnesville and Woodsfield Berea grit pools have been so defined by dry holes that there is little opportunity for important extensions. In the Barnesville pool wells drilled 20 years ago are still producing, their long life being attributed to the judicious spacing of the wells, most of which are 1,000 feet or more apart.

An attempt was made to develop an oil field along Captina Creek 1 mile east of the area represented on the map, at a locality known as Hogsink. Several small "pumpers" were drilled, but most of them have been abandoned. Southwest of this locality, toward Newcastle, Belmont County, a show of oil is reported in several Berea wells. Since the completion of this report a small oil well in the Berea sand has been drilled on the Evans farm, 1 mile east of Newcastle.

The only producing area deriving oil or gas from the Berea sand, aside from those already mentioned, is at and southeast of Beallsville, where a small gas field designated the Schriver pool has recently been discovered. Well 249 at Beallsville is a small producer and is separated from the pool to the southeast by several dry holes. The closed pressure of the wells in the gas field averages about 700 pounds and the initial yield of a number of the wells was about 3,000,000 cubic feet a day. At the east edge of this field, beyond the area represented on the map, the rocks form a gently southeastward-sloping, terraced embayment where oil may possibly be discovered.

The precise structural features of oil sands other than the Berea can not be gathered from an inspection of the map, because the Berea sand does not lie parallel to the Big Injun sand and other strata nearer the surface. It is evident, however, that in the extremely productive area that occupies so much of the southern half of the quadrangle the rocks have a comparatively uniform southeastward slope, with few terraces or cross flexures to vary the monotony. There is a suggestion of alignment of the productive areas along the strike of the rocks, as is illustrated by the wells in the Keener sand from Malaga southwestward past Miltonsburg to the Cooper pool, 1 mile southeast of Monroefield, and this alignment will doubtless be increasingly evident when the production is extended by future drilling. It seems highly probable that several of the gaps, especially the one along the east side of Miltonsburg, will in time be closed. There are, however, other pools whose longer dimensions extend at right angles to the strike of the rocks, suggesting that the shape of the pool is controlled by the trend of a lenticular pay sand. In many pools of seemingly abnormal shape and trend the production does not come from a single pay sand, but rather from two or more beds in the same formation, or possibly in different formations. The productive sand in each well is designated so far as possible on the map, but the oil in many wells is derived from two or even three sands. This is true of certain wells in the vicinity of Decker station, east of Lewisville.

With the above-stated facts in mind it may be said in conclusion that extensions are probable in many of the small pools and that the search should be continued along the strike of the rocks, or, in other words, parallel to the structural contours. A map representing the lay of the shallow sands is now in preparation and will be included in a future report, in which detailed attention will be given to the oil fields and also to coal and other mineral resources.

QUALITY OF THE OILS.

The oils of this region are shown by analyses to be of best Pennsylvania grade, ranging from 36° to 50° Baumé in gravity and from light amber to dark green in color. Asphalt and sulphur are lacking, and the percentage of paraffin ranges from 2.5 to more than 10. A number of analyses have been published by the United States Geological Survey.[1]

PUBLICATIONS.

A list of United States Geological Survey bulletins concerning oil and gas fields in eastern Ohio and adjacent parts of West Virginia and Pennsylvania is given on page 231.

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[1] U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 1212-1217, 1914.

ANALYSES OF COAL SAMPLES FROM VARIOUS PARTS OF THE UNITED STATES.

By MARIUS R. CAMPBELL and FRANK R. CLARK.

INTRODUCTION.

The accompanying table gives the analyses of all coal samples collected by the United States Geological Survey in 1914 and that part of the year 1915 ending May 31. The analyses were made at the Pittsburgh laboratory of the Bureau of Mines, and to that organization belongs the credit and responsibility for the accuracy of the chemical work.

In the course of a year many coal fields are examined in reconnaissance or in detail by members of the United States Geological Survey. The fields in the eastern part of the country are surveyed for the purpose of determining the amount and quality of the coal, in order that the public may be made acquainted with the fuel resources of the United States. In the public-land States of the West the examinations are made in part for a similar purpose and in part (in late years this has been the controlling influence) to gather data for the classification of the land as mineral or nonmineral according to its coal content. If the land is classified as coal land a valuation must be assigned to it in accordance with certain regulations adopted by the Department of the Interior, which take into account both the quantity and quality of the coal. The quantity of coal is determined by a general survey of the field and the quality by chemical analysis and by calorimeter determination of samples sent by the geologist to the chemical laboratory.

Most of these analyses will be published in the descriptions of the fields from which the samples were obtained, but as such reports will necessarily be delayed until all the data gathered in the field have been thoroughly classified and digested, they may not appear for several months or perhaps more than a year. In order to make the analyses immediately available to the public they have been grouped according to States and counties and are herewith published in advance of the reports to which they relate. The samples of coal from Virginia, Tennessee, Illinois, and Missouri were collected by the United States Geological Survey in cooperation with the geological surveys of these States.

Many of the samples, especially those from the public-land States, were collected in fields in which mining either has not begun or has attained only a small development. Under such conditions it is difficult, if not impossible, to procure fresh material, and hence the analyses may show coal of lower grade than would appear if the sample were made up of strictly unweathered coal. In the table the analyses of weathered samples are marked so as to warn the reader against basing important conclusions on the figures given. They should be used with caution and only until such time as they may be replaced by the analyses of fresh material.

The geologist taking a sample of coal for analysis is instructed to procure unweathered material if possible. He is supposed to face up the bed in the mine or prospect until fresh coal is available, and then to obtain the sample by making a uniform cut across the bed from roof to floor. He is expected to cut sufficient coal to give at least 6 pounds to the foot of coal bed sampled. The sample thus obtained is hastily pulverized in the mine until it will pass through a ½-inch mesh screen and then is quartered down to about 4 pounds in weight. This sample is placed in a galvanized-iron can, which is sealed with adhesive tape and mailed to the laboratory for analysis. The geologist proceeds on the principle that a coal mine should be sampled as carefully as a gold mine and that the sample should be even more carefully handled after it has been taken. The object of sealing is mainly to prevent change in the moisture content, so that the coal may reach the laboratory in practically the same condition as it leaves the mine. Coal is a very unstable substance, and great care must be exercised to prevent the taking on or giving off of moisture and its oxidation in the course of preparation and in transit. It is also important that the sample should consist of neither the best nor the poorest coal, but that it should be representative of the output of the mine, if one is in operation, or, if the field is undeveloped, it should represent as nearly as possible the merchantable coal that may be procured at some time in the future when mining is carried on.

Although the aim of the geologist in sampling by the method specified above is to obtain coal that is representative of the output of the mine, experience has shown that this aim is seldom or never accomplished. Almost invariably the sample obtained in the mine contains a lower percentage of impurities than the coal which reaches the consumer. This difference is due largely to carelessness in mining and handling and probably could be mostly eliminated were conditions of mining more nearly ideal. By comparing a large number of samples taken in a mine with samples from the same mine taken at the point of consumption, it has been found that there is a fairly constant but small difference in the percentages of moisture, ash, and sulphur, and that almost invariably the amounts of these substances in the mine samples are less than in the coal that reaches the market. On this account the sulphur as given in the analyses should be increased by about 1 per cent of itself and the ash by 1½ per cent of itself to represent correctly the sulphur and the ash in merchantable coal from the mines.

In the table the analyses are given in four forms, marked A, B, C, and D. Analysis A represents the sample as it comes from the mine. This form is not well suited for determining the relative merits of a fuel, because the amount of moisture in a sample of coal as it comes from the mine is largely a matter of accident, and consequently analyses of the same coal expressed in this form may vary as widely as the analyses of coal from different beds or from different fields. Analysis B represents the sample after it has been dried at a temperature of 86° to 95° Fahrenheit until its weight becomes constant. This form of analysis probably represents the coal in the most stable form that it can be put by natural or artificial means and therefore is the one best adapted to general purposes of comparison in order to determine relative fuel values. Analysis C represents the coal after all moisture has been eliminated, and analysis D the coal after all moisture and ash have been theoretically removed. The latter is supposed to represent the true coal substance, free from the most significant impurities. Forms C and D are obtained from the others merely by recalculation. They are useful to the mechanical engineer who desires to reduce his fuel theoretically to a stable, unchanging form in order to test or check the performance of his apparatus and also in a study of the pure coal substance, free from all impurities, but as this substance is not the same as the coal that reaches the bin of the consumer neither forms C nor D should be used in determining the relative practical fuel values of coals.

The analyses reported from the laboratory have been somewhat generalized, as it is commonly recognized that the figures representing the different percentages are not generally correct to the second decimal place or to the ultimate unit. This is particularly true of the proximate analysis, and therefore the air-drying loss, moisture, volatile matter, fixed carbon, and ash are given to one decimal place only; and the ash (in the ultimate analysis), sulphur, hydrogen, carbon, nitrogen, and oxygen are given to two decimal places. The determination of the calorific value to individual units is not reliable, hence in the column headed "Calories" the values are given to the nearest five units, and in the column headed "British thermal units" they are given to the nearest tens, as the value of a British thermal unit is about one-half that of a calorie.

CLASSIFICATION OF COAL.

The separation of coals into various classes, such as bituminous, semibituminous, and lignite, is practiced in the trade, but so far no one has devised a satisfactory or systematic basis for such a classification. Many have attempted to classify coals on their chemical composition alone, and for the higher grade coals this plan seems to be fairly satisfactory, but it does not apply to the lower-rank bituminous, subbituminous, and lignite coals, or at least no one has yet proposed a scheme of separation which fits these coals and corresponds with the physical differences that have been observed by all who use them or are concerned with their mining or exploitation. Recent analytical work done on some of the so-called anthracites of southwestern Virginia (see analyses 19357–19360, 19431, 19924, 20721, and 20722) shows that chemically they are nothing more than semibituminous coal, but their physical characteristics seem to rank them with the semianthracites. It seems probable that both chemical and physical properties must be taken into account in framing a classification that will have any practical value. The classes of coal generally recognized in the United States and the criteria used by the Geological Survey for their differentiation and separation are as follows:

Anthracite.—The characteristics of anthracite are generally so well known that they need no detailed description. The coal is hard and has a vitreous or metallic luster. It is high in fixed carbon, the fuel ratio (fixed carbon divided by the volatile matter) being not less than 10. Most of this kind of coal comes from the anthracite fields of eastern Pennsylvania, but small areas are known in some of the Western States, where the coal has been changed to anthracite by the heat or pressure of intruded masses of igneous rocks.

Semianthracite coal.—Semianthracite coal is regarded in the trade as the lowest grade of anthracite. It resembles anthracite in that it is distinctly harder than ordinary bituminous coal and has some of the vitreous luster of the higher-grade coal. Its fuel ratio is supposed to range from 6 or 7 to 10. These limits are arbitrary, however, and are intended to represent the distinctions made in the trade, but as stated in the description of analyses from Virginia, it is very uncertain whether the lower limit should be fixed by some arbitrary fuel ratio or whether it should be determined by the physical properties of the coal in conjunction with its fuel ratio. This question can be answered only by a more thorough study of this kind of coal than has yet been given to it and the collection of more analyses bearing on the question. There is only a small amount of semianthracite in the United States. It occurs in isolated basins along the eastern front of the great Appalachian trough, where the rocks have been subjected to great pressures, or in the West in the proximity of igneous rocks.

Semibituminous coal.—Semibituminous coal is of great commercial importance but is not widely distributed. Its fuel ratio ranges from 3 to 6 or 7, and on account of its relatively high fixed carbon it is generally known to the trade as "smokeless" coal. It has the highest calorific value and is the best coal of the country for the generation of steam. Much of it can be utilized for the manufacture of coke, but for this use it is not best suited, for the reason that the amount of volatile matter is scarcely sufficient to bind the particles of carbon together into a firm and homogeneous coke. The centers of production of semibituminous coal are the Pocahontas and New River fields of Virginia and West Virginia, the Georges Creek field of Maryland, the Windber field of Pennsylvania, and the west end of the Arkansas field, in the vicinity of Fort Smith. Coal of this rank has been found in the West, especially in Washington, but the areas are small and the output comparatively insignificant.

Bituminous coal.—Bituminous coal is the most generally useful and important rank of coal in the country and includes most of the coals east of the Rocky Mountains. In the Western States there are large areas of bituminous coal, such as the Raton Mesa region of Colorado and New Mexico; the Grand Hogback field of Colorado; the Book Cliffs field of Utah; the Rock Springs, Kemmerer, and Black Hills fields of Wyoming; the Great Falls field of Montana; the Eden Ridge field in Coos County, Oreg.; and many districts in Washington. Coal of this rank furnishes most of the coking coal of the country and is largely used for steam raising and for domestic purposes.

Subbituminous coal.—The name "subbituminous" has been adopted by the Geological Survey for that rank of coal which has generally been called "black lignite." The term lignite for coal of this kind is objectionable, for the reason that it is not lignitic in the sense of being perceptibly woody, and the use of that term seems to imply that it is little better in quality than the brown, woody lignite of North Dakota or Texas, whereas many of the coals of this rank closely approach bituminous coal in quality. It is, in fact, extremely difficult to say where the line separating coal of this rank from the lignite below and the bituminous coal above should be drawn. It is generally distinguishable from the lignite by its black color and its freedom from apparent woody structure, and from bituminous coal by the slacking it undergoes when exposed to the weather. As slacking is an important difference in commercial use, it has been adopted by the Geological Survey as the criterion for the separation of subbituminous and bituminous coals.

Subbituminous coal is found in most of the Western States, being well known in the Boulder, North Park, and Yampa fields, Colorado; the Gallup field, New Mexico; the Hanna, Douglas, Sheridan, and Bighorn Basin fields, Wyoming; the Red Lodge and Musselshell fields, Montana; and many of the districts of Washington and Oregon.

Lignite.—The word "lignite," as used by the Geological Survey, is restricted to coals that are distinctly brown and generally woody. Lignite is characterized by the great amount of water that it carries and is intermediate in quality between peat and subbituminous coal. It is abundant in eastern Montana and North Dakota and in the northwest corner of South Dakota. In the South it is commercially developed only in Texas, but it is known to be present in small quantities in the other Gulf States as far east as Alabama.

DESCRIPTION OF SAMPLES.

COLORADO.

ELBERT COUNTY.

19992. Subbituminous coal from strip pit of Wright Barker, sec. 21, T. 10 S., R. 58 W., 4 miles east of Mattison station, on Chicago, Rock Island & Pacific Railroad. Pit worked only to supply local demands. Coal bed, Upper Cretaceous age; Laramie formation. Sample only slightly weathered; cut at back end of pit September 28, 1914, by M. R. Campbell. Section is as follows:

	Feet.
Coal and carbonaceous shale	3
Coal, soft	2
Coal, hard (sampled)	5
Coal, hard	4
	14

LA PLATA COUNTY.

20268. Bituminous coal from drift mine of Andrew Hauert, in sec. 7, T. 35 N., R. 12 W., 6 miles southeast of Mancos station on Rio Grande Southern Railroad. Coal bed, Spencer; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale and sandstone. Sample cut 60 feet from mouth November 14, 1914, by A. J. Collier. Section at point sampled is as follows:

	Ft.	in.
Coal	1	4
Shale		10
Coal (sampled)	1	1
Shale (sampled)		½
Coal (sampled)	1	2
Coal, bony (sampled)		3
Coal (sampled)	2	9
	7	5½

MONTEZUMA COUNTY.

20267. Bituminous coal from drift mine of G. S. Todd, in sec. 25, T. 35 N., R. 16 W., 6 miles southeast of Cortez and 18 miles southwest of Mancos station, on Rio Grande Southern Railroad. Coal bed, Spencer; Upper Cretaceous age; Mesaverde formation. The bed dips about 2° S. Roof and floor are shale and sandstone. Sample cut in room on left 85 feet from mine mouth October 28, 1914, by A. J. Collier; represents 3 feet 11 inches of coal, entire thickness of bed.

20498. Bituminous coal from Old Spencer (drift) mine of E. J. Freeman, in sec. 3, T. 35 N., R. 13 W., 2 miles southeast of Mancos station, on Rio Grande Southern Railroad. Coal bed, Peacock; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Sample cut in north entry 700 feet from mine mouth October 8, 1914, by A. J. Collier; represents 2 feet 4 inches of coal, entire thickness of bed.

20500. Bituminous coal from same mine as No. 20498. Coal bed, Spencer; Upper Cretaceous age; Mesaverde formation. Roof is shale and floor is sandstone. Sample cut in right entry 500 feet from mine mouth October 9, 1914, by A. J. Collier. Section at point sampled is as follows:

	Ft.	in.
Coal, Spencer (sampled)	3	1
Coal, bony		6
Sandstone	35	0
Coal (Peacock)	2	4
	40	11

20499. Bituminous coal from drift mine of Spencer & Fielding, in sec. 2, T. 35 N., R. 13 W., 2 miles southeast of Mancos station, on Rio Grande Southern Railroad. Coal bed, Spencer; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample cut in right entry 400 feet from mine mouth October 8, 1914, by O. B. Hopkins; represents 2 feet 9 inches of coal, entire thickness of bed.

MONTANA.

CHOUTEAU COUNTY.

19790. Subbituminous coal from the mine of John Deda, in sec. 6, T. 24 N., R. 13 E., 16 miles southeast of Virgelle station, on Great Falls branch of Great Northern Railway. Coal bed, Upper Cretaceous age; Eagle sandstone. Roof and floor are shale. Sample taken in entry about 175 feet southeast of mine mouth August 28, 1914, by E. Russell Lloyd. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		7¾
Bone		2¼
Coal (sampled)	1	8
	2	6

19795. Subbituminous coal from mine of Price Sexton, in sec. 17, T. 24 N., R. 13 E., 20 miles southeast of Virgelle station, on Great Falls branch of Great Northern Railway. Coal bed, Upper Cretaceous age; Eagle sandstone. The roof and floor are shale. Sample cut 50 feet south of mine mouth September 4, 1914, by E. Russell Lloyd; represents 1 foot 5 inches of coal, entire thickness of bed. Coal slightly weathered.

DAWSON COUNTY.

19923. Subbituminous coal from Foster prospect, on Big Dry Creek in sec. 18, T. 18 N., R. 38 E., 1 mile west of Jordan, a small town 90 miles northwest of Miles City, which is on the Chicago, Milwaukee & St. Paul and Northern Pacific railways. Coal bed, no name; Tertiary (Eocene) age; Fort Union formation. Roof is sandstone and floor is shale. Sample taken from side wall of drift 50 feet from mouth and 15 feet from face of drift October 4, 1914, by C. F. Bowen. The coal was dry and probably slightly weathered. Section at point sampled is as follows:

	Ft.	in.
Coal		2½
Shale, carbonaceous		2
Coal		2
Sandstone		½
Coal	1	3
Shale		8
Coal (sampled)	2	4
Shale		2
Coal (sampled)		5½
Bone		1½
Coal (sampled)		8
	6	3

FALLON COUNTY.

20370. Lignite from the open-cut mine of G. A. Horner, in sec. 12, T. 3 S., R. 62 E., 4½ miles northwest of Camp Crook, S. Dak., a small inland town 60 miles southwest of Bowman, S. Dak., a station on the Chicago, Milwaukee & St. Paul Railway. Coal bed, Kerr; Tertiary (Eocene) age; Fort Union formation. The bed lies flat. Roof is sandstone and floor is clay. Sample cut at face of an open pit November 24, 1914, by E. M. Parks. Section at point sampled is as follows:

	Ft.	in.
Lignite, poor (sampled)		4
Lignite, brown, woody (sampled)	1	7
Bone (sampled)		1
Lignite (sampled)		6
Lignite, bony		6
Lignite (sampled)	1	2
Clay		5½
Lignite (sampled)		4
Clay		½
Lignite (sampled)		8½
	5	8½

20372. Lignite from the open-cut mine of J. S. Kerr, in sec. 11, T. 3 S., R. 62 E., 4½ miles northwest of Camp Crook, S. Dak., a small town 60 miles southwest of Bowman, a station on the Chicago, Milwaukee & St. Paul Railway. Coal bed, Kerr; Tertiary (Eocene) age; Fort Union formation. Bed lies flat. Roof and floor are shale. Sample taken at surface of an open pit November 24, 1914, by E. M. Parks. Section at point sampled is as follows:

	Ft.	in.
Lignite, brown, woody (sampled)	2	4
Lignite, shaly (sampled)		7
Lignite, brown, woody (sampled)		11
Shale (sampled)		¾
Lignite (sampled)		8
Shale		1¾
Lignite, brown	1	3
	5	11½

[illegible] 1914, by C. T. Lupton. [illegible] as follows:

	Ft.	in.
[illegible]	1	4
[illegible]		[illegible]
[illegible]	2	[illegible]
	4	[illegible]

[illegible] Lupton. Section [illegible]

	Ft.	in.
[illegible]	1	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]	2	[illegible]
	[illegible]	[illegible]

[illegible]

NEW MEXICO—Continued.

	Ft.	in.
Coal (sampled)		11
Sandstone		1½
Coal (sampled)	6	3
	7	3½

19134. Subbituminous coal from same mine as No. 19131. Coal bed, No. 5; Upper Cretaceous age; Mesaverde formation. Bed dips 12° NW. Roof and floor are shale. Sample dry; cut 1,300 feet N. 55° W. of mouth of No. 5 slope April 8, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal, bony		5
Coal		4
Coal, bony	1	2
Coal (sampled)	5	3½
	7	2½

19135. Composite[1] of samples 19133 and 19134.

19136. Subbituminous coal from Bartlett (shaft) mine of Victor-American Fuel Co., in the NE. ¼ sec. 9, T. 15 N., R. 18 W., 1½ miles north of Gallup, on spur of Atchison, Topeka & Santa Fe Railway. Coal bed, Black Diamond (?); Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Bed dips 11° W. Sample dry; cut 430 feet south of shaft landing April 8, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	3
Sandstone		1½
Coal (sampled)	1	8
Bone		2
Coal (sampled)	1	9
	5	11½

19137. Subbituminous coal from Weaver (slope) mine of Victor-American Fuel Co., at Gibson, N. Mex., on a branch of the Atchison, Topeka & Santa Fe Railway, in the NE. ¼ sec. 34, T. 16 N., R. 18 W., 3 miles north of Gallup. Coal bed, No. 2; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Bed dips 11° N. Sample dry; cut 3,900 feet N. 6° W. of mine mouth April 7, 1914, by C. T. Lupton; represents 3 feet 8 inches of coal, entire thickness of bed at point sampled.

19138. Subbituminous coal from same mine as No. 19137. Coal bed, No. 3; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Bed dips 7° N. Sample dry; cut 3,450 feet N. 12° W. of mine mouth April 7, 1914, by C. T. Lupton; represents 4 feet 11 inches of coal, entire thickness of bed.

19139. Subbituminous coal from same mine as No. 19137. Coal bed, No. 3½; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Sample dry; cut 2,750 feet N. 2° W. of mine mouth April 7, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal, bony (sampled)		11
Coal (sampled)		7
Bone		6
Coal (sampled)	3	8
	5	8

19140. Subbituminous coal from same mine as No. 19137. Coal bed, No. 5; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Sample dry; cut 2,800 feet N. 42° W. of mine mouth April 7, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Bone		5½
Coal, bony		5
Coal (sampled)	5	2
	6	½

19162. Subbituminous coal from Gallup Southwestern mine of Gallup Coal Mining Co., in the SE. ¼ sec. 21, T. 15 N., R. 18 W., 1 mile south of Gallup, on spur of Atchison, Topeka & Santa Fe Railway. Coal bed, Black Diamond; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. The bed dips 20° W. Sample dry; cut 1,200 feet south of mine mouth April 10, 1914, by C. T.

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[1] A sample obtained in the laboratory by thoroughly mixing equal weights of two or more face samples.

NEW MEXICO—Continued.

Lupton. Section of coal bed at point sampled is as follows:

	Ft.	in.
Coal		2
Bone		2
Coal (sampled)		10
Bone		1½
Sandstone		2
Coal (sampled)	3	11
	5	4½

19163. Subbituminous coal from mine of Dominic Carreto, in the SW. ¼ sec. 14, T. 15 N., R. 18 W., 1¼ miles east of Gallup station, on Atchison, Topeka & Santa Fe Railway. Coal bed, Otero (?); Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Sample dry; cut 350 feet S. 15° E. of mine mouth April 10, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal		4
Shale		3
Coal (sampled)	3	2
	3	9

19212. Subbituminous coal from mine of Myers Bros., in the SE. ¼ sec. 21, T. 15 N., R. 19 W., 8 miles west of Gallup station, on Atchison, Topeka & Santa Fe Railway. Coal bed, Myers; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Bed dips 3° NE. Sample dry; cut 205 feet N. 45° W. of mine mouth April 15, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal, hard and very bony		3
Coal, slightly bony (sampled)		2
Coal (sampled)	2	4
Bone		1
	2	10

19217. Subbituminous coal from Diamond (shaft) mine of Diamond Coal Co., in the SW. ¼ sec. 18, T. 15 N., R. 18 W., at Allison, on spur of Atchison, Topeka & Santa Fe Railway. Coal bed, Aztec (?); Upper Cretaceous age; Mesaverde formation. Roof is bone and coal; floor is sandstone. Bed is flat. Sample dry; cut about 2,600 feet N. 55° W. of shaft landing April 14, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	4
Bone		½
Coal (sampled)	2	8½
	4	1

19218. Subbituminous coal from same mine as No. 19217. Coal bed, Aztec (?); Upper Cretaceous age; Mesaverde formation. Bed dips 3° N. Sample dry; cut 1,400 feet S. 85° W. of shaft landing April 14, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	0
Bone		3
Coal, bony		6
Coal (sampled)		7½
Bone		½
Coal (sampled)		11
Coal, bony		4
Coal (sampled)	2	3
	5	11

19219. Subbituminous coal from same mine as No. 19217. Coal bed, Aztec (?); Upper Cretaceous age; Mesaverde formation. Roof is shale and sandstone and floor is shale. Bed dips 2° S. 70° E. Sample dry; cut 3,300 feet N. 45° E. of shaft landing April 14, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal and bone interbedded	1	0
Coal (sampled)		11
Bone		¾
Coal (sampled)	3	9
Bone		3½
Coal (sampled)	2	2½
	8	2¾

19220. Composite of samples 19217, 19218, and 19219.

19221. Subbituminous coal from mine of A. Jones & Co., in the NW. ¼ sec. 22, T. 15 N., R. 19 W., 7 miles slightly south of west of Gallup station, on Atchison, Topeka & Santa Fe Railway. Coal bed, Defiance; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample damp; cut 250 feet north of mine mouth April 11, 1914, by C. T.

NEW MEXICO—Continued.

Lupton; represents 2 feet 6 inches of coal, entire thickness of bed.

19222. Subbituminous coal from shaft mine of John Beddow, in the SW. ¼ sec. 8, T. 15 N., R. 18 W., 1½ miles northwest of Gallup station, on Atchison, Topeka & Santa Fe Railway. Coal bed, Aztec (?); Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Bed dips 2° E. Sample dry; cut 300 feet west of shaft landing April 14, 1914, by C. T. Lupton; represents 3 feet 10½ inches of coal, entire thickness of bed.

19223. Subbituminous coal from Defiance mine, in the NE. ¼ sec. 16, T. 15 N., R. 19 W., 6 miles west of Gallup and about 2 miles north of Atchison, Topeka & Santa Fe Railway. Coal bed, Defiance; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Bed dips 4° E. Sample dry; cut about 880 feet N. 85° E. of mine mouth April 11, 1914, by C. T. Lupton; represents 5 feet 9½ inches of coal, entire thickness of bed.

19286. Subbituminous coal from Heaton (slope) mine of Victor-American Fuel Co., in the NW. ¼ sec. 35, T. 16 N., R. 18 W., 4 miles northeast of Gallup, on spur of Atchison, Topeka & Santa Fe Railway. Coal bed, No. 2; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample dry; cut 2,300 feet N. 30° W. of slope mouth April 23, 1914, by C. T. Lupton; represents 2 feet 11 inches of coal, entire thickness of bed.

19287. Subbituminous coal from same mine as No. 19286. Coal bed, No. 3½; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample dry; cut 3,300 feet N. 15° W. of mine mouth April 23, 1914, by C. T. Lupton; represents 3 feet 11 inches of coal, entire thickness of bed.

19288. Subbituminous coal from same mine as No. 19286. Coal bed, No. 3; Upper Cretaceous age; Mesaverde formation. Sample dry; cut 4,000 feet N. 37° W. of mine mouth April 23, 1914, by C. T. Lupton. Section at point sampled is as follows:

	Ft.	in.
Coal, bony		7
Coal (sampled)	2	4
Coal, bony		8
Coal (sampled)		5
	4	0

SOCORRO COUNTY.

20007. Bituminous coal from prospect drift in sec. 8, T. 2 N., R. 6 W., about 32 miles northwest of Magdalena station, on a branch of Atchison, Topeka & Santa Fe Railway. Coal bed, no name; upper Cretaceous age; Mancos (?) shale. Roof is sandstone and floor is shale. Bed dips 4° SW. Sample wet; taken at face of drift 15 feet long, which was made at the time of sampling, October 22, 1914, by Dean E. Winchester. Section at point sampled is as follows:

	Ft.	in.
Coal		9
Shale		4
Coal (sampled)	1	2
Shale		4
Coal (sampled)	1	9
	4	4

NORTH DAKOTA.

MORTON COUNTY.

19786. Lignite from open-cut mine of T. A. Ramsland, in the NW. ¼ sec. 6, T. 137 N., R. 86 W., 5 miles southwest of Almont station, on Northern Pacific Railway. Coal bed, no name; Tertiary (Eocene) age; Fort Union formation. Sample cut from south wall of open pit August 24, 1914, by E. T. Hancock. Section at point sampled is as follows:

	Ft.	in.
Lignite (sampled)	3	11
Lignite	1	8
Shale, brown		4½
Lignite		10
	6	9½

19801. Lignite from mine in SW. ¼ sec. 32, T. 138 N., R. 84 W., 8 miles south and 2 miles west of Judson station, on Northern Pacific Railway. Coal bed, no name;

NORTH DAKOTA—Continued.

Tertiary (Eocene) age; Fort Union formation. Bed lies flat. Roof is sandstone and floor is shale. Sample wet; cut 70 feet N. 15° W. of shaft landing September 7, 1914, by E. T. Hancock. Bed is 6 feet 8 inches thick, but as part of bed was weathered, sample represents only 4 feet 2 inches of the lower part of the bed.

20033. Lignite from mine (slope) of Dakota Products Co., in sec. 15, T. 139 N., R. 85 W., on spur of Northern Pacific Railway, half a mile northeast of New Salem, N. Dak. Coal bed, no name; Tertiary (Eocene) age; Fort Union formation. Roof is lignite and floor is shale. Bed lies flat. Sample wet; cut 2,040 feet northwest of mine mouth October 23, 1914, by E. T. Hancock. Section at point sampled is as follows:

	Ft.	in.
Lignite (sampled)	1	4
Lignite, shaly (sampled)		4
Lignite (sampled)	3	1
	4	9

This section represents only the lower part of the bed, as the roof of the mine is composed of lignite.

OHIO.

BELMONT COUNTY.

20174. Bituminous coal from mine of J. H. Milhoan, in sec. 7, T. 7 N., R. 5 W., Goshen Township, 1½ miles northeast of Hunter, 5 miles south of Bethesda station, on Baltimore & Ohio Railroad. Coal bed, Waynesburg; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are shale. Sample dry; cut 50 feet south of mine mouth November 21, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	1½
Bone (sampled)		1½
Coal (sampled)		11
	3	2

20176. Bituminous coal from mine of Thomas Davy, in sec. 20, T. 8 N., R. 6 W., Warren Township, 1 mile southwest of Barnesville station, on Baltimore & Ohio Railroad. Coal bed, Meigs Creek (Sewickley); Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is coal and floor is shale. Sample dry; cut 350 feet southwest of mine mouth November 20, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal, impure		10
Clay	1	2
Coal (sampled)	3	2
Bone		2
	5	4

20187. Bituminous coal from Cochran mine No. 2 of Bixler (Ohio) Coal Co., in sec. 31, T. 8 N., R. 6 W., Warren Township, at Baileys Mills, on Baltimore & Ohio Railroad 3½ miles southwest of Barnesville. Coal bed, Pittsburgh; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is shale and floor is clay. Sample cut at face of main north entry, 1 mile north of mine mouth, November 25, 1914, by R. V. A. Mills. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		9
"Sulphur"		1
Coal (sampled)	2	11
	3	9

20188. Bituminous coal from same mine as No. 20187. Coal bed, Pittsburgh; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is shale and floor is clay. Sample cut in room 6 off No. 15 west entry, three-quarters of a mile north of mine mouth, November 25, 1914, by R. V. A. Mills. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	1
"Sulphur"		1
Coal; some "sulphur" (sampled).		2
Coal (sampled)		3
Bone (sampled)		1
Coal (sampled)		6
"Sulphur" (sampled)		¼
Coal (sampled)	2	
	4	2¼

20189. Composite of samples 20187 and 20188.

OHIO—Continued.

20230. Bituminous coal from Jeeffries mine, Temperanceville, in sec. 33, T. 7 N., R. 6 W., Somerset Township, 4 miles south of Baileys Mills station, on Baltimore & Ohio Railroad. Coal bed, Pittsburgh; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is shale and floor is clay. Sample dry; cut 600 feet north of mine mouth November 22, 1914, by R. V. A. Mills. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		7½
"Soot" streak		½
Coal (sampled)		4½
Bone		½
Coal (sampled)	1	7
"Sulphur"		½
Coal (sampled)	1	
	3	8½

20234. Bituminous coal from mine of Howard Brown, in sec. 26, T. 6 N., R. 5 W., Wayne Township, 2 miles southeast of Somerton and 8 miles southeast of Barnesville station, on Baltimore & Ohio Railroad. Coal bed, Waynesburg; Carboniferous (Pennsylvanian) age; Monongahela formation. Sample cut 100 feet west of mine mouth November 24, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		6
"Sulphur"		1
Coal (sampled)	1	
"Soot"		½
Coal (sampled)		11
	2	6½

20236. Bituminous coal from Stoffel mine of Nathan Davis, in sec. 27, T. 5 N., R. 4 W., Washington Township, 1 mile southwest of Alledonia station, on Ohio River & Western Railroad (narrow gage). Coal bed, Waynesburg; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are shale. Sample dry; cut 50 feet southwest of mine mouth November 26, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in
Bone		4
Coal (sampled)	2	5½
	2	9½

20237. Bituminous coal from mine of Shipman Bros., in sec. 22, T. 5 N., R. 4 W., Washington Township, 1 mile north of Alledonia station, on Ohio River & Western Railroad (narrow gage). Coal bed, Meigs Creek (Sewickley); Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is clay and limestone; floor is shale. Sample dry; cut 40 feet west of mine mouth November 26, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	1
Coal, bony cannel (sampled)		2½
Coal (sampled)		1½
Clay		½
Coal (sampled)	1	6
	3	11½

20238. Bituminous coal from mine of S. A. Moore, in sec. 33, T. 5 N., R. 4 W., Washington Township, 1½ miles southwest of Alledonia station, on Ohio River & Western Railroad (narrow gage). Coal bed, Washington; Carboniferous (Permian?) age; Washington formation. Roof and floor are shale. Sample dry; cut 50 feet east of mine mouth November 26, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal, bony		3
Coal, bony in lower part (sampled)	2	1
Clay		8
Coal (sampled)		11
	3	11

20241. Bituminous coal from mine of George Thomas, in sec. 14, T. 7 N., R. 6 W., Somerset Township, 2 miles east of Boston, 7 miles south of Barnesville station, on Baltimore & Ohio Railroad. Coal bed, Waynesburg; Carboniferous (Pennsylvanian) age; Monongahela formation.

OHIO—Continued.

Roof is sandstone and floor is shale. Sample dry; cut 200 feet south of mine mouth November 24, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	0
"Sulphur"		2
Coal (sampled)		10
"Soot"		1
Coal (sampled)		11
	3	0

20775. Bituminous coal from prospect of Peter Kemp, in sec. 1, T. 7 N., R. 5 W., Goshen Township, 2 miles east of Hunter and 5 miles southeast of Bethesda station, on Baltimore & Ohio Railroad. Coal bed, Uniontown; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are clay. Sample dry and weathered; cut 20 feet west of mine mouth November 21, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	6
Shale		1
Coal (sampled)		3
Shale		5
Coal (sampled)		7
	3	10

GUERNSEY COUNTY.

20178. Bituminous coal from mine of Samuel Sayre, in sec. 21, T. 9 N., R. 7 W., Millwood Township, 1½ miles northwest of Quaker City station, on Baltimore & Ohio Railroad. Coal bed, Pittsburgh; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is shale and floor is clay. Sample dry; cut 250 feet east of mine mouth November 20, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal, bony		4
Coal (sampled)		9
"Sulphur"		1
Coal (sampled)	1	8
Shale		½
Coal (sampled)		3½
Shale		½
Coal (sampled)		11
	4	1½

20243. Bituminous coal from mine of Andy Slovak, in sec. 11, T. 8 N., R. 9 W., Valley Township, 1 mile southeast of Hartford, on spur of Baltimore & Ohio Railroad. Coal bed, Anderson (Bakerstown); Carboniferous (Pennsylvanian) age; Conemaugh formation. Roof is sandstone and floor is shale. Sample cut 75 feet east of mine mouth November 27, 1914, by D. Dale Condit; represents 1 foot 10 inches of coal, entire thickness of bed.

20245. Bituminous coal from Waldhonding No. 2 (shaft) mine of Cambridge Colliery Co., in sec. 11, T. 8 N., R. 9 W., Valley Township, 1 mile southeast of Hartford, on spur of Baltimore & Ohio Railroad. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample cut 600 feet southeast of shaft landing November 27, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		2
"Soot" (sampled)		¼
Coal (sampled)		8
"Soot"		½
Coal (sampled)	2	0
"Soot"		½
Coal (sampled)		7
"Soot" (sampled)		¼
Coal (sampled)		8
Clay		¼
Coal (sampled)		6
Bone		1½
Coal (sampled)	1	2
	6	¼

20246. Bituminous coal from same mine as No. 20245. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample cut 3,400 feet northwest of shaft landing November 27, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	9
"Soot"		½
Coal (sampled)	1	6
"Soot" (sampled)		¼
Coal (sampled)		4

OHIO—Continued.

	Ft.	in.
"Soot"		½
Coal (sampled)		9
Bone		1
Coal (sampled)		10
	5	4½

20247. Composite of samples 20245 and 20246.

20261. Bituminous coal from Cleveland (shaft) mine of Morris Coal Co., in sec. 21, T. 1 N., R. 2 W., Richland Township, a quarter of a mile southeast of Senecaville, on branch of Baltimore & Ohio Railroad. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample cut in room No. 5 east off main north entry, 5,200 feet east of shaft landing, November 28, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	6
"Soot" (sampled)		¼
Coal (sampled)		8
Bone		1
Coal (sampled)		7
"Soot" (sampled)		¼
Coal (sampled)		4
"Soot" (sampled)		¼
Coal (sampled)		8
Bone		2
Coal (sampled)		9
"Soot"		½
Coal (sampled)		4
"Soot"		½
Coal (sampled)		9
	5	11¾

20262. Bituminous coal from same mine as No. 20261. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample cut 10,500 feet north of shaft landing November 28, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		8
"Soot" (sampled)		½
Coal (sampled)	1	0
"Soot" (sampled)		½
Coal (sampled)		7
Bone		¾
Coal (sampled)		6
"Soot" (sampled)		¼
Coal (sampled)		8
"Soot" (sampled)		¼
Coal (sampled)		6
Bone		2
Coal (sampled)		4
Bone		1
Coal (sampled)		7
	5	3½

20263. Composite of samples 20261 and 20262.

20264. Bituminous coal from Black Top (shaft) mine of Morris Coal Co., in sec. 8, T. 1 N., R. 2 W., Richland Township, 1 mile west of Lore City, on spur of Baltimore & Ohio Railroad. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample dry; cut in No. 23 east entry, off main south entry, 6,200 feet S. 15° E. of shaft landing, November 28, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	6
Coal, bony (sampled)		1½
Coal (sampled)	1	2½
Bone		2
Coal (sampled)		10
	4	10

20265. Bituminous coal from same mine as No. 20264. Coal bed, Upper Freeport; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample dry; cut near end of main south entry, 7,300 feet S. 12° W. of shaft landing, November 28, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	3
Coal, bony (sampled)		2½
Coal (sampled)	1	7
Bone		2½
Coal (sampled)	1	9
	6	0

20266. Composite of samples 20264 and 20265.

OHIO—Continued.

JEFFERSON COUNTY.

15394. Bituminous coal from Amsterdam mine of Youghiogheny & Ohio Coal Co., in SW. ¼ sec. 18, T. 11 N., R. 4 W., half a mile south of Amsterdam. Sampled December 27, 1912, by D. Dale Condit. Composite of Nos. 15388, 15389, and 15390.[1]

15395. Bituminous coal from Eastern Ohio mine of Rice Coal Co., in the NE. ¼ sec. 8, T. 12 N., R. 4 W., 2 miles northeast of Amsterdam. Sampled December 28, 1912, by D. Dale Condit. Composite of Nos. 15391, 15392, and 15393.[1]

15442. Bituminous coal from Elizabeth mine of Wolf Run Coal Co., in the SE. ¼ sec. 7, T. 12 N., R. 4 W., 1½ miles east of Amsterdam. Sampled December 30, 1912, by D. Dale Condit. Composite of Nos. 15440 and 15441.[1]

15446. Bituminous coal from Parlett mine of Etta Coal Co., in SE. ¼ sec. 32, T. 9 N., R. 3 W., 2 miles southeast of Hopedale. Sampled December 31, 1912, by D. Dale Condit. Composite of Nos. 15444[2] and 15445.[1]

15565. Bituminous coal from Goucher No. 2 mine of Dexter Coal Co., in the SE. ¼ sec. 6, T. 5 N., R. 2 W., 1½ miles northwest of Brilliant. Sampled January 4, 1913, by D. Dale Condit. Composite of Nos. 15563 and 15564.[1]

MONROE COUNTY.

20259. Bituminous coal from mine of Charles Mobley, in sec. 31, T. 4 N., R. 4 W., Adams Township, 2½ miles east of Coats station, on Ohio River & Western Railroad (narrow gage). Coal bed, Uniontown; Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are shale. Sample cut 40 feet east of mouth November 27, 1914, by D. Dale Condit. Sample dry. Section at point sampled is as follows:

	Ft.	in.
Coal, bony at top (sampled)	1	7
Shale		3½
Coal (sampled)		10½
Shale		2
Coal (sampled)		6
	3	5

NOBLE COUNTY.

20185. Bituminous coal from mine of G. W. Griffin, in sec. 11, T. 8 N., R. 7 W., Beaver Township, 3 miles southeast of Quaker City station, on the Baltimore & Ohio Railroad. Coal bed, Meigs Creek (Sewickley); Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are shale. Sample dry; cut 350 feet west of mine mouth November 22, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	5
Clay		2
Coal (sampled)	1	2
	3	9

20235. Bituminous coal from mine of Wiley Carter, in sec. 33, T. 8 N., R. 8 W., Seneca Township, 1 mile north of Mount Ephraim station on Ohio River & Western Railroad (narrow gage). Coal bed, Meigs Creek (Sewickley); Carboniferous (Pennsylvanian) age; Monongahela formation. Roof and floor are shale. Sample cut 300 feet west of mouth November 26, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		11
"Soot"		¾
Coal (sampled)		10
"Soot"		1
Coal (sampled)	1	4
	3	2¾

20240. Bituminous coal from mine of J. T. Moore, in sec. 11, T. 7 N., R. 8 W., Marion Township, 1 mile west of Steam-

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[1] For analyses of original samples see U. S. Geol. Survey Bull. 531, pp. 344-346, 1913.

[2] The thickness of the coal bed represented by sample 15444 is 4 feet 6 inches instead of 2 feet 6 inches, as stated by a typographic error in Bulletin 531, p. 346.

OHIO—Continued.

town station, on Ohio River & Western Railroad (narrow gage). Coal bed, Meigs Creek (Sewickley); Carboniferous (Pennsylvanian) age; Monongahela formation. Roof is clay and floor is shale. Sample cut 480 feet south of mine mouth November 26, 1914, by D. Dale Condit. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		11
"Soot"		½
Coal (sampled)	2	
"Soot"		1
Coal (sampled)	1	
	4	½

OKLAHOMA.

CRAIG COUNTY.

20715. Bituminous coal from strip pit of J. A. Mills, in sec. 28, T. 28 N., R. 20 E., 4 miles west of Welch station, on Missouri, Kansas & Texas Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is shale and floor is clay. Sample cut in face of open pit December 12, 1914, by Carl D. Smith; sample represents 2 feet 2 inches of coal, entire thickness of bed.

20716. Bituminous coal from drift mine of James Coates in sec. 26, T. 27 N., R. 20 E., 4 miles west of Bluejacket station on Missouri, Kansas & Texas Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is shaly sandstone and floor is clay. Sample cut just off east side of main entry, 300 feet from mine mouth, December 13, 1914, by Carl D. Smith; represents 3 feet 1 inch of coal, entire thickness of bed.

20717. Bituminous coal from strip pit of Mr. Heldebrand, in sec. 13, T. 26 N., R. 19 E., 10 miles northwest of Vinita station, on Missouri, Kansas & Texas Railway and St. Louis & San Francisco Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is shale and sandstone; floor is clay. Sample cut in face of open pit December 14, 1914, by Carl D. Smith; represents 2 feet 3 inches of coal, entire thickness of bed.

20718. Bituminous coal from strip pit of William Boot, in sec. 33, T. 26 N., R. 19 E., 1 mile east of Estella; no railroad connection. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Sample cut in face of open pit December 14, 1914, by Carl D. Smith; represents 2 feet of coal, entire thickness of bed.

ROGERS COUNTY.

20714. Bituminous coal from strip pit of New State Coal Co., in sec. 21, T. 22 N., R. 14 E., half a mile north of Collinsville, on Atchison, Topeka & Santa Fe Railway. Coal bed, Dawson; Carboniferous (Pennsylvanian) age; Coffeyville (?) formation. Shale above and clay below. Sample cut at face of open pit December 10, 1914, by Carl D. Smith; represents 1 foot 9 inches of coal, entire thickness of bed.

20780. Bituminous coal from shaft mine No. 1, of Catale Coal Co., in sec. 14, T. 24 N., R. 18 E., 1 mile northeast of Catale, a station on the St. Louis & San Francisco Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is hard shale; floor is clay. Sample cut 300 feet northwest of shaft December 15, 1914, by Carl D. Smith; represents 1 foot 10 inches of coal, entire thickness of bed. Depth below surface at point of sampling, 70 feet.

20781. Bituminous coal from slope mine of A. P. McNutt, in sec. 22, T. 22 N., R. 16 E., 5 miles northeast of Claremore, a station on the St. Louis & San Francisco and St. Louis, Iron Mountain & Southern railways. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is shale; floor is clay. Sample cut in slope 50 feet north of mine mouth December 17, 1914, by Carl D. Smith; represents 1 foot 7 inches of coal, entire thickness of bed. Depth below surface at point of sampling, 25 feet.

OKLAHOMA—Continued.

TULSA COUNTY.

20712. Bituminous coal from mine No. 1 (slope) of Southwestern Coal Co., in sec. 28, T. 20 N., R. 13 E., half a mile west of Dawson, on St. Louis & San Francisco Railroad. Coal bed, Dawson; Carboniferous (Pennsylvanian) age; Coffeyville (?) formation. Roof and floor are shale. Sample cut 500 feet north of slope mouth December 9, 1914, by Carl D. Smith; represents 2 feet of coal, entire thickness of bed.

20713. Bituminous coal from No. 2 (shaft) mine of Hickory Coal & Mining Co., in sec. 17, T. 19 N., R. 13 E., 4 miles southeast of Tulsa, on Missouri, Kansas & Texas Railway. Coal bed, Dawson; Carboniferous (Pennsylvanian) age; Coffeyville (?) formation. Roof and floor are shale. Sample cut 300 feet southeast of shaft landing December 9, 1914, by Carl D. Smith. Sample represents 2 feet 6½ inches of coal, entire thickness of bed.

WAGONER COUNTY.

20832. Bituminous coal from strip pit of the Arkansas Valley Coal, Gas & Oil Co., in sec. 15, T. 18 N., R. 15 E., 3½ miles northeast of Broken Arrow station, on the Missouri, Kansas & Texas Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Cherokee formation. Roof is shale and floor is clay. Sample cut from open pit December 19, 1914, by Carl D. Smith; represents 2 feet of coal which contains some sulphur bands, entire thickness of bed.

OREGON.

COOS COUNTY.

19877. Bituminous coal from prospect on Pulford claim, in SW. ¼ sec. 20, T. 32 S., R. 11 W., Eden Ridge field, 35 miles west of West Fork station, on Southern Pacific Railroad. Coal bed, Anderson; Tertiary (Eocene) age; Arago formation. Roof is shale overlain by massive sandstone; floor is shale. Bed dips 16° S. Sample cut in drift 125 feet from mouth and 4 feet from face September 22, 1914, by C. E. Lesher. Section at point sampled is as follows:

	Ft.	in.
Coal, bony (sampled)		11½
Coal (sampled)		5
Coal, bony (sampled)		4
Clay		2½
Coal (sampled)		2
Bone (sampled)		¾
Coal, bony (sampled)		2¼
Coal (sampled)		4
Bone		8
Black coaly mud (sample 19878)	1	8
	5	0

19878. Bituminous coal from same prospect and location as No. 19877. Sample represents lower bench.

PENNSYLVANIA.

SOMERSET COUNTY.

19848. Semibituminous coal from Cairnbrook mine of Loyalhanna Coal & Coke Co., on Pennsylvania Railroad at Cairnbrook. Coal bed, lower Kittanning (B) bed; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof and floor are shale. Sample cut in "empty" southeast entry September 18, 1914, by G. B. Richardson. Section at point sampled is as follows:

	Ft.	in.
Coal, bony		10
Coal (sampled)	3	2
Coal, bony		8
	4	8

19849. Semibituminous coal from same mine as No. 19848. Coal bed, Lower Kittanning (B) bed; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof and floor are shale. Sample cut in "loaded" south entry September 18, 1914,

PENNSYLVANIA—Continued.

by G. B. Richardson. Section at point sampled is as follows:

	Ft.	in.
Coal, bony	1	3
Coal (sampled)	3	2
Coal, bony	1	7
	6	0

19850. Composite of samples 19848 and 19849.

19851. Semibituminous coal from mine of Irving Fleegle (old Hitchens mine), 2¼ miles southeast of Cairnbrook station on Pennsylvania Railroad. Coal bed, Brookville (A) bed; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof and floor are shale. Sample cut in small entry west of main entry, 300 feet from mine mouth, September 18, 1914, by G. B. Richardson. Section at point sampled is as follows:

	Ft.	in.
Bone		4
Coal (sampled)	1	0
Shale		5½
Coal (sampled)	1	6
	3	3½

TENNESSEE.

In accordance with an agreement with the Tennessee Geological Survey for the cooperative investigation of the coals of the State all the commercially productive mines of the State were sampled by the United States Geological Survey in 1915, the work being done by F. R. Clark.

ANDERSON COUNTY.

21427. Bituminous coal from mine (wagon) of Alexander Hall, 1½ miles north-northeast of Oliver Springs, on Louisville & Nashville Railroad and Southern Railway. Coal is fresh. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample dry; cut at face of main entry, 400 feet east of mouth, March 11, 1915, by F. R. Clark. Section of coal bed at point sampled is as follows:

	Ft.	in.
Coal, massive, hard, and blocky (sampled)	1	10
Coal, containing some rash (sampled)		2
	2	0

21451. Bituminous coal from drift mine of Piedmont Coal & Coke Co., 3 miles north-northeast of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample dry; cut at face of Moore's place off Pigankle entry, 1,200 feet north of mouth, March 11, 1915, by F. R. Clark. Section of coal bed at point sampled is as follows:

	Ft.	in.
Rash, coal, and sulphur mixed		5
Clay		3
Coal, massive and blocky (sampled)	1	11
	2	7

21452. Bituminous coal from same mine and bed as No. 21451. Sample dry; cut at face of room 18 off No. 6 right entry, 4,000 feet north-northwest, 1,325 feet east-northeast, and 200 feet south-southeast from mouth, March 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal lenses interbedded		5
Coal, massive and brittle (sampled)	4	5
	4	10

21453. Bituminous coal from same mine and bed as No. 21451. Sample dry; cut at face of No. 1 room (left) off No. 3 right entry, 2,200 feet north-northwest, 800 feet east-northeast, and 45 feet north-northwest from mouth, March 11, 1915, by F. R. Clark. Section of bed sampled shows 4 feet 6 inches of massive coal containing thin lenses of sulphur.

21455. Composite of samples 21451, 21452, and 21453.

TENNESSEE—Continued.

21454. Bituminous coal from same mine and bed as No. 21451. Sample dry; cut at mouth of No. 5 right entry, 3,000 feet north-northwest of mouth, March 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		2
Clay		1½
Coal, cannel (?) (sampled)		11
Coal, massive and blocky	1	3½
	2	6

21627. Bituminous coal from Smith mine (wagon), 1½ miles west of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. This small mine is operated continuously, but the coal at the point sampled was slightly weathered. Coal bed, not identified; Carboniferous (Pennsylvanian) age; Wartburg sandstone (?). Sample dry; cut at face of No. 1 right off main entry, 75 feet north of mouth, March 13, 1915, by F. R. Clark; represents 2 feet of coal, entire thickness of bed.

21628. Bituminous coal from Thistle (drift) mine of Coal Creek Coal Co., 3 miles southwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample dry; cut at face of No. 2 right off main face entry, 1,200 feet S. 30° W. of mouth of Dogwood opening, March 13, 1915, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)		2¾
Rash (sampled)		¼
Coal and rash interbedded (sampled)		4½
Coal, bright and blocky (sampled)		4½
Coal, very dull and hard, cannel-like (sampled)		2
Coal, bright and blocky (sampled)	2	10
Coal		2
	4	2

21629. Bituminous coal from same mine and bed as No. 21628. Sample dry; cut at face of room 63 off No. 5 left entry, 1,980 feet S. 72° W. of mouth, March 12, 1915, by F. R. Clark; represents entire thickness of bed. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, soft and blocky		9
Coal, very dull and hard (cannel in character)		6
Coal, massive and hard	2	11
	4	2

21630. Bituminous coal from same mine and bed as No. 21628. Sample dry; cut in face of room 8 off No. 4 left entry off No. 5 left entry, 2,380 feet S. 52° W. of mouth, March 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal laminated (sampled)	1	1
Coal, very dull and very hard (sampled)		4
Coal, massive, hard, and blocky (sampled)	2	11
	4	4

21631. Composite of samples 21628, 21629, and 21630.

21636. Bituminous coal from Fraterville (drift) mine of Coal Creek Coal Co., 1½ miles southwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample dry; cut at face of room 2 off No. 14 right off new main entry, 5,560 feet N. 40° W. of mouth, March 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		3
Coal, massive and blocky (sampled)	3	3
Shale or clay		6
Coal, massive and blocky (sampled)		7
	4	7

TENNESSEE—Continued.

Can containing sample was broken in transit and coal reached laboratory loose in mail pouch. Coal may be slightly altered.

21637. Bituminous coal from same mine and bed as No. 21636. Sample dry; cut from room No. 3 off No. 14 right off new main entry, 5,700 feet N. 38° W. of mouth, March 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and rash (sampled)		9
Coal, massive but crushed (sampled)	2	10
Shale		7
Coal, good (sampled)		5
	4	7

21638. Bituminous coal from same mine and bed as No. 21636. Sample dry; cut at face of room 3 off No. 16 left off old main entry, 4,900 feet N. 71° W. of mouth, March 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and rash (sampled)		9
Coal, massive but crushed (sampled)	2	10
	3	7

21639. A composite of samples 21636, 21637, and 21638.

21632. Bituminous coal from Tennessee (drift) mine of Royal Consolidated Coal Co., 5 miles southwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample damp; cut on pillar A off main entry, 2,840 feet S. 40° W. of mouth, March 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, crushed (sampled)		6
Coal and some rash (sampled)		1
Coal, massive but crushed (sampled)	3	1
	3	10

21633. Bituminous coal from same mine and bed at No. 21632. Sample damp; cut at face of room 1 off entry No. 625 on Minersville side, 4,040 feet S. 57° W. of mouth, March 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, with considerable rash intermixed (sampled)	1	11
Shale or clay		10
Coal, massive but crushed (sampled)	2	
	4	11

21634. Bituminous coal from same mine and bed as No. 21632. Sample dry; cut at face of room 1 off No. 11 right entry, 4,060 feet S. 88° W. of mouth, March 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		3
Clay		2
Coal, badly crushed (sampled)	1	2
Clay and rash		3
Coal, bright (sampled)		5
Clay		3
Coal, massive (sampled)	2	8
	5	2

21635. A composite of samples 21632, 21633, and 21634.

21680. Bituminous coal from Middle Ridge (drift) mine of Royal Consolidated Coal Co., 4½ miles southwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample wet and slightly weathered; cut from rib on left main entry 100 feet southwest of mouth, March 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal		2

TENNESSEE—Continued.

	Ft.	in.
Rash		2
Coal (sampled)	3	5
	3	11

21640. Bituminous coal from Klondike (slope) mine of Black Diamond Coal Co., 3 miles north-northwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of main entry, 7,700 feet N. 65° W. of mouth, March 15, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal		2
Coal, massive and hard (sampled)	3	6
Shale		8
Coal, massive (sampled)		6
	4	10

21641. Bituminous coal from same mine and bed as No. 21640. Sample dry; cut at face of No. 30 left entry, 7,500 feet S. 39° W. of mouth, March 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	3	9
Shale		9
Coal, massive (sampled)		7
Rash		1
	5	2

21642. Bituminous coal from same mine and bed as No. 21640. Sample dry; cut at face of No. 22 left entry, 7,900 feet S. 39° W. of mouth, March 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal		8
Coal, dull and hard (sampled)	1	3
Rash		1½
Coal, bright and hard (sampled)	1	5½
Clay		½
Coal (sampled)		2
Clay		½
Coal (sampled)		1½
Shale		8½
Coal (sampled)		7
Rash		2
	5	4

21643. Bituminous coal from same mine and bed as No. 21640. Sample dry; cut at face of room 32 off No. 26 left entry, 7,600 feet S. 39° W. of mouth, March 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		2½
Sulphur lens		2
Rash and coal		3
Coal, dull and very hard (sampled)	1	8
Coal, bright with dull bands (sampled)	1	11
Shale		3
Coal, bright and hard (sampled)		10
	5	3½

21644. A composite of samples 21640, 21641, 21642, and 21643.

21645. Bituminous coal from Black Diamond (drift) mine No. 1 of Black Diamond Coal Co., 3 miles north-northwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale, and floor is shale and clay. Sample dry; cut from pillar 25 off No. 1 right off No. 12 east entry, 10,900 feet S. 22° W. of mouth, March 17, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, rashy (sampled)		4½
Rash		½
Coal, massive with dull bands (sampled)	3	2
	3	7

21646. Bituminous coal from same mine and bed as No. 21645. Sample dry; cut at face of room 11 off No. 7 right off No. 12 east entry, 9,500 feet south of mouth,

TENNESSEE—Continued.

March 17, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		4
Rash		½
Coal, blocky (sampled)	1	7
Rash		½
Coal, massive and hard (sampled)	1	7
	3	7

21647. Bituminous coal from same mine and bed as No. 21645. Sample dry; cut at face of No. 4 left, off No. 10, west entry, 8,200 feet S. 40° W. of mouth, March 17, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash, containing lenses of coal		6
Coal, hard and massive (sampled)	2	8
Shale		6
Rash		2
	3	10

21648. Bituminous coal from same mine and bed as No. 21645. Sample dry; cut at face of No. 1 airway off No. 1 left off No. 10 west entry, 8,900 feet S. 24° W. of mouth, March 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		5
Rash		2
Coal, hard and massive (sampled)	3	
	3	7

21649. Composite of samples 21645, 21646, 21647, and 21648.

BLEDSOE COUNTY.

22259. Bituminous coal from Atpontley drift mine of Lusk Coal Mining Co., 1 mile north of Atpontley, on spur of Pikeville branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is shale. Sample dry; cut at face of Lusk entry, 1,000 feet southwest of mouth, May 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, with bands of coal interbedded		4
Coal, lustrous, banded and crushed (sampled)	3	6
Rash		6
Coal		10
	5	2

22260. Bituminous coal from same mine and bed as No. 22259. Sample dry; cut at face of Smith's room off Lusk entry, 1,200 feet west-southwest of mouth, May 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, banded and soft (sampled)		7
Coal, bright and hard (sampled)		10
Coal, bright and badly crushed (sampled)	1	8
Rash		6
Coal		10
	4	6

22261. Composite of samples 22259 and 22260.

CAMPBELL COUNTY.

21650. Bituminous coal from Cambria (drift) mine of Royal Consolidated Coal Co., 4 miles north-northwest of Coal Creek, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of room No. 1 off No. 16, left entry, 5,280 feet N. 18° W. and 100 feet S. 72° W. from mouth, March 15, 1915, by F. R. Clark; represents entire thickness of bed. Section of bed at point sampled shows 3 feet 4½ inches of massive hard coal containing thin bands of dull coal.

21651. Bituminous coal from same mine and bed as No. 21650. Sample dry; cut at face of room 5 off No. 17½, right entry, 5,280 feet N. 18° W. and 500 feet N. 72° E. from mouth, March 15, 1915, by

TENNESSEE—Continued.

F. R. Clark. Section of coal bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, massive and hard (sampled)	2	10
	3	0

21652. Bituminous coal from same mine and bed as No. 21650. Sample dry; cut on pillar 9 off No. 21 left entry, 6,280 feet N. 18° W. and 500 feet S. 72° W. from mouth, March 15, 1915, by F. R. Clark. Sample represents 3 feet 2 inches of hard, massive coal, entire thickness of bed.

21653. Composite of samples 21650 to 21652, inclusive.

21654. Bituminous coal from Sun (drift) mine of Sun Coal Co., 1½ miles southwest of Caryville, on Southern Railway. Coal bed, Red Ash; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandy shale and floor is clay. Sample cut at face of room 30 off No. 10 right entry, 2,500 feet north-northwest, 1,400 feet north-northeast, 550 feet east-southeast, and 50 feet south from mouth, March 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	1	4½
Clay		1
Coal, bright and hard (sampled)	1	4½
Clay		3
Coal, bright (sampled)		1½
	3	2½

21655. Bituminous coal from same mine and bed as No. 21654. Sample cut at face of No. 17 right entry, 4,000 feet west and 900 feet north from mouth, March 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Bony coal		2
Coal, massive and hard (sampled)	1	4
Coal, very dull and hard (sampled)		1
Coal, bright, hard, and blocky (sampled)	2	1
Clay		4
Coal (sampled)		2
	4	4

21656. Bituminous coal from same mine and bed as No. 21654. Sample cut at face of No. 14 left entry, 2,900 feet west, 1,300 feet south, and 100 feet west from mouth, March 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, hard, bright, and massive (sampled)	2	0
Clay		2
Coal, bright, hard, and massive (sampled)	1	3
Clay		4
Coal, bright and hard (sampled)		2
	3	11

21657. Bituminous coal from same mine and bed as No. 21654. Sample cut at face of room 5 off No. 17 left entry, 3,700 feet west and 200 feet south from mouth, March 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		3
Coal (sampled)	2	8
Shale		1
Coal (sampled)	1	
Clay		3½
Coal (sampled)		2
	4	5½

21658. Composite of samples 21654 to 21657, inclusive.

21677. Bituminous coal from Pee Wee, a (drift) mine of Sun Coal Co., 1½ miles southwest of Caryville, on Southern Railway. Coal bed, Lower Dean; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandy shale and floor is clay. Sample cut in room 1 off main haulage way, 150 feet southwest, 100 feet south, 700 feet east, and 450 feet northeast from mouth, March 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	3	½
Rash		4
	3	4½

TENNESSEE—Continued.

21678. Bituminous coal from same mine and bed as No. 21677. Sample dry; cut at face of No. 4 right entry, 150 feet southwest, 100 feet south, and 700 feet southwest from mouth, March 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	10
Rash		2
Clay		5
Coal (sampled)		2
Clay		5½
Rash		½
Coal, bright (sampled)		5
	4	6

21679. Composite of samples 21677 and 21678.

21659. Bituminous coal from Caryville (drift) mine of New Caryville Coal Co., 1½ miles northwest of Caryville, on Southern Railway. Coal bed, Red Ash; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is shale and floor is clay. Sample wet; cut in face of room 6 off No. 4 right entry, 1,150 feet west of mouth, March 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal		3
Coal, bright, hard, and massive (sampled)	1	4
Coal, rashy (sampled)		1
Coal, bright and blocky (sampled)	1	11
Clay		4
Coal		2
	4	1

21660. Bituminous coal from same mine and bed as No. 21659. Roof is sandy shale and floor is clay. Sample dry; cut at face of room 3 off No. 10 left entry, 1,850 feet S. 75° W. of mouth, March 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, rashy (sampled)		3
Coal, massive, bright, and hard (sampled)	1	3½
Shale and rash		1
Coal, massive and blocky (sampled)	1	8
Coal and clay interbedded		6
	3	9½

21661. Bituminous coal from same mine and bed as No. 21659. Sample dry; cut at face of room 5 off No. 15 left entry, 3,275 feet S. 75° W. of mouth, March 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and very hard (sampled)	1	6
Clay and rash		½
Coal, massive and blocky (sampled)	1	10½
Clay and rash		2
Coal		1
	3	8

21662. Bituminous coal from same mine and bed as No. 21659. Sample dry; cut at face of room 3 off No. 15 right entry, 3,875 feet west of mouth, March 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and clay interbedded		2
Coal (sampled)	1	9
Clay		¾
Coal (sampled)	1	9
Clay		2
Coal		1
	3	11¾

21663. Composite of samples 21659 to 21662, inclusive.

21664. Bituminous coal (weathered) from Disney prospect, 1½ miles southwest of Vasper, on Southern Railway. Coal bed, Frozen Head (?); Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandstone and floor is clay. Sample dry; cut from rib in main entry near face, 150 feet south of mouth, March 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, coal, and carbonaceous shale, interbedded		2
Clay		2

TENNESSEE—Continued.

	Ft.	in.
Rash		1
Coal, bright, with dull bands (sampled)	3	1
Clay		1
Coal (sampled)		2
	3	9

21668. Bituminous coal from Red Ash (drift) mine of Red Ash Coal Co., 1¾ miles north-northwest of Caryville, on Southern Railway. Coal bed, Red Ash; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandstone and floor is clay. Sample wet; cut at face of room 1 off No. 15 right entry off No. 1 haulage way, 2,550 feet west of mouth, March 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay and coal interbedded		1½
Coal (sampled)	1	8
Shale		½
Coal (sampled)	1	7
	3	5

21669. Bituminous coal from same mine and bed as No. 21668. Roof is sandy shale and floor is clay. Sample wet; cut at face of No. 9 left entry off No. 1 haulage way, 3,025 feet west of mouth, March 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, carbonaceous		1
Coal, bright and hard (sampled)	1	1
Coal, rashy (sampled)		1
Coal, bright and hard (sampled)		9
Rash		3
Coal, bright and hard (sampled)	1	3
	3	6

21670. Bituminous coal from same mine and bed as No. 21668. Sample dry; cut at face of room 1 off No. 7½ left entry, 2,050 feet west of mouth, March 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	2	9½
Clay (cut by machine)		5
	3	2½

21671. Bituminous coal from same mine and bed as No. 21668. Sample dry; cut at face of room 7 off No. 4 right entry, 1,250 feet west and 1,400 feet north from mouth, March 22, 1915, by F. R. Clark; represents 3 feet 3 inches of massive, blocky coal, total thickness of bed.

21672. Composite of samples 21668 to 21671, inclusive.

21665. Bituminous coal from Vasper (slope) mine of Vasper Coal Co., half a mile west of Vasper, on Southern Railway. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandstone and floor is clay. Sample dry; cut at face of main entry, 1,400 feet southwest of mouth, March 18, 1915, by F. R. Clark; represents 3 feet 10½ inches of hard, massive coal, entire thickness of bed.

21666. Bituminous coal from same mine and bed as No. 21665. Sample dry; cut at face of No. 1 right off main entry, 800 feet west and 260 feet north from mouth, March 18, 1915, by F. R. Clark; represents 3 feet 4 inches of good, clean, massive coal, total thickness of bed.

21667. Composite of samples 21665 and 21666.

21673. Bituminous coal from Bear Wallow (drift) mine of the Bear Wallow Coal & Coke Co., 1½ miles southwest of Caryville, on the Southern Railway. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of main entry, 3,000 feet S. 85° W. of mouth, March 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	1	11
Coal, very dull and hard (sampled)		1
Coal, bright and hard (sampled)		6
	2	6

21674. Bituminous coal from same mine and bed as No. 21673. Sample dry; cut at face of No. 9 left entry, 2,200 feet S. 85° W. and 1,000 feet S. 5° E. from mouth, March 23, 1915, by F. R. Clark;

TENNESSEE—Continued.

represents 2 feet 4 inches of massive, hard coal, entire thickness of bed.

21675. Bituminous coal from same mine and bed as No. 21673. Roof is sandstone and floor is clay. Sample dry; cut at face of room 6 off No. 7 right entry, 2,050 feet S. 85° W. and 900 feet N. 5° W. from mouth, March 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		1½
Coal, rashy (sampled)		1½
Coal, bright and hard (sampled)		10
Rash		1
Coal (sampled)	1	10
	3	0

21676. Composite of samples 21673 to 21675, inclusive.

21687. Bituminous coal from Southern (drift) mine of Southern Coal & Coke Co., 2,000 feet west of Cotula, on Louisville & Nashville Railroad. Coal bed, Jordan; Carboniferous (Pennsylvanian) age; Wartburg sandstone. Roof is shale and floor is clay. Sample dry; cut at face of room 4 off A entry, 1,200 feet S. 20° W. of mouth, March 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and blocky (sampled)		11
Coal, rashy (sampled)		2
Coal, bright and blocky (sampled)	3	6
	4	7

21688. Bituminous coal from same mine and bed as No. 21687. Sample dry; cut at face of a room off main entry 75 feet southwest of mouth of the E entry, or 1,700 feet S. 60° W. of mine mouth, March 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and blocky (sampled)		9
Rash		2
Coal, massive and bright (sampled)		8½
Rash and mineral charcoal [1]		1
Coal, bright, hard, and brittle (sampled)	2	5
	4	1½

21689. Composite of samples 21687 and 21688.

21690. Bituminous coal from Wynn (drift) mine of Wynn Coal Co., 1 mile south of Cotula, on Louisville & Nashville Railroad. Coal bed, Rich Mountain; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut at face of room 36 off No. 2 left entry, 250 feet west, 4,000 feet south, and 50 feet west from mouth, March 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	1	4
Rash		5
Coal, massive and blocky (sampled)	1	4
	3	1

21691. Bituminous coal from same mine and bed as No. 21690. Sample dry; cut at face of No. 5 right entry, 1,000 feet west, 1,300 feet south, 400 feet west, and 250 feet north from mouth, March 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	2
Rash		2
Coal, bright and brittle (sampled)		8
Coal, with thin bands of mineral charcoal (sampled)		1
Coal, bright and hard (sampled)	1	2
	3	3

21692. Bituminous coal from same mine and bed as No. 21690. Sample dry; cut at face of main entry, 1,000 feet west, 1,300 feet south, and 650 feet west from mouth, March 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	1	3
Rash		3
Coal, bright and hard (sampled)	1	3
Rash		4
	3	1

21693. Composite of samples 21690 to 21692, inclusive.

21694. Bituminous coal from Gem No. 4 (drift) mine of Lafollette Coal, Iron &

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[1] Commonly called "mother of coal" by the miners.

TENNESSEE—Continued.

Railway Co., 2 miles northeast of Kilsyth, on Louisville & Nashville Railroad. Coal bed, Jordan; Carboniferous (Pennsylvanian) age; Wartburg sandstone. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 2 right entry, 600 feet N. 11° 15′ W. and 550 feet N. 38° 45′ W. from mouth, March 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, bright and hard (sampled)	3	2½
Clay and rash		4
	3	7½

21695. Bituminous coal from same mine and bed as No. 21694. Sample dry; cut at face of No. 3 left entry, 1,050 feet N. 11° 15′ W. and 175 feet S. 78° 45′ W. from mouth, March 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	3	5½
Rash and coal interbedded		8
	4	1½

21696. Bituminous coal from Gem No. 2 (drift) mine of Lafollette Coal, Iron & Railway Co., 2 miles northeast of Kilsyth, on Louisville & Nashville Railroad. Coal bed, Jordan; Carboniferous (Pennsylvanian) age; Wartburg sandstone. Sample dry; cut in room No. 2 off No. 7 left entry, 1,450 feet N. 23° W., 1,300 feet N. 11° 15′ W., 180 feet S. 38° 45′ W., and 150 feet S 11° 15′ E. from mouth, March 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, massive and hard (sampled)	4	4
	4	6

21697. Bituminous coal from same mine and bed as No. 21696. Roof is shale and floor is clay. Sample dry; cut at face of No. 8 right entry, 1,450 feet N. 23° W., 1,850 feet N. 11° 15′ W., and 150 feet N. 38° 45′ E. from mouth, March 25, 1915. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal interbedded		2
Coal, massive and hard (sampled)	3	2
	3	4

21698. Composite of samples 21694 to 21697, inclusive.

21699. Bituminous coal from Rex No. 1 (slope) mine of Lafollette Coal, Iron & Railway Co., 2 miles north-northeast of Lafollette, on Louisville & Nashville Railroad. Coal bed, Rex; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut at face of No. 1 left entry, 4,500 feet N. 37° W., 1,325 feet N. 24° E., and 800 feet N. 66° W. from mouth, March 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		1
Coal, bright and brittle (sampled)	3	10
Rash		1
	4	0

21700. Bituminous coal from same mine and bed as No. 21699. Sample dry; cut at face of main entry, 4,500 feet N. 37° W. and 2,550 feet N. 66° W. from mouth, March 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, with thin lenses of coal interbedded		4
Coal, massive and brittle (sampled)	2	7
	2	11

21701. Bituminous coal from same mine and bed as No. 21699. Roof is sandstone and floor is clay. Sample dry; cut at face of No. 2 right entry, 2,400 feet N. 37° W., 2,125 feet N. 53° E., 1,875 feet N. 24° E., and 1,775 feet S. 66° E. from mouth, March 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, cannel		10
Coal, bright		5
Shale	2	2
Coal, bright (sampled)	2	9
	6	2

TENNESSEE—Continued.

21702. Bituminous coal from same mine and bed as No. 21699. Sample dry; cut at face of No. 2 left main entry, 2,400 feet N. 37° W., 2,125 feet N. 53° E., 1,875 feet N. 24° E., and 2,900 feet N. 66° W. from mouth, March 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, cannel-like (sampled)		2
Coal, soft, containing thin lenses of pyrite (sampled)		10
Coal, massive and brittle (sampled)	2	8
	3	8

21703. A composite of samples 21699 to 21702, inclusive.

21802. Bituminous coal from Remy (drift) mine of Remy Coal Co., 2 miles southeast of Habersham, on Louisville & Nashville Railroad. Coal bed, Rich Mountain; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 12 right entry, 3,100 feet from mouth, March 29, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		8
Clay		8
Coal, massive and hard (sampled)	2	4½
Rash		4
	4	½

21803. Bituminous coal from same mine and bed as No. 21802. Sample dry; cut at face of No. 13 left entry, 3,400 feet from mouth, March 29, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	9
Rash		5
	3	2

21804. Bituminous coal from same mine and bed as No. 21802. Sample dry; cut at face of No. 11½ left entry, 2,800 feet from mouth, March 29, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	2	7
Rash		3
	2	10

21805. Composite of samples 21802 to 21804, inclusive.

21806. Bituminous coal from Rich Mountain (drift) mine of Rich Mountain Coal & Coke Co., 1 mile east of Habersham, on Louisville & Nashville Railroad. Coal bed, Rich Mountain; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut at face of No. 7 left entry, 2,150 feet S. 30° E. and 800 feet N. 60° E. from mouth, March 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and brittle (sampled)	1	8
Coal, soft and laminated (sampled)		6
Rash		1½
Coal (sampled)		1½
	2	5

21807. Bituminous coal from same mine and bed as No. 21806. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 4 left entry, 1,200 feet S. 30° E. and 1,300 feet N. 60° E. from mouth, March 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	1	8
Coal, laminated and soft (sampled)		10
	2	6

21808. Bituminous coal from same mine and bed as No. 21806. Sample dry; cut at face of No. 8 right entry, 2,450 feet S. 30° E. and 400 feet S. 60° W. from mouth, March 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and brittle (sampled)	2	4
Shale and lenses of coal interbedded		7
Coal, bright and brittle (sampled)		3
Coal, impure, high in ash		7

TENNESSEE—Continued.

	Ft.	in.
Coal, bright and brittle (sampled)		6
Clay and rash		3
	4	6

21809. Bituminous coal from same mine and bed as No. 21806. Sample dry; cut at face of No. 9 left entry, 2,650 feet S. 30° E. and 200 feet N. 60° E. from mouth, March 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright, hard, and blocky (sampled)	2	7
Rash		4
Coal, bright and laminated (sampled)		6
Coal, rashy		2
Coal, bright		1
	3	8

21810. Composite of samples 21806 to 21809, inclusive.

21811. Bituminous coal from Chaska (drift) mine of Chaska Coal Co., 3,600 feet southeast of Chaska, on Louisville & Nashville Railroad. Coal bed, Rich Mountain; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut from pillar off main entry 400 feet east of mouth, April 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	2	6
Clay		10
Coal, hard and blocky (sampled)		10
	4	2

21812. Bituminous coal from same mine and bed as No. 21811. Sample dry; cut in room 1 off No. 1 right entry, 300 feet southeast of mouth, April 1, 1915, by F. R. Clark; represents 2 feet 8 inches of hard, massive coal, entire thickness of bed.

21813. Bituminous coal from same mine and bed as No. 21811. Sample wet; cut from main entry of panhandle side, 600 feet southwest of mouth, April 1, 1915, by F. R. Clark; represents 2 feet 8 inches of coal, entire thickness of bed.

21814. Composite of samples 21811 to 21813, inclusive.

21821. Bituminous coal from Kimberly (drift) mine of Kimberly Coal Co., half a mile east of Kimberly, on Louisville & Nashville Railroad. Coal bed, Rich Mountain; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample damp; cut at face of No. 10 left entry March 31, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard, containing thin bands of sulphur (sampled)	1	9
Rash		1
Coal, bright and hard (sampled)		7
Rash		2
	2	7

21822. Bituminous coal from same mine and bed as No. 21821. Sample cut at face of No. 3 right entry off new main entry March 31, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, hard and blocky (sampled)	2	1
Rash		½
Coal, bright and hard (sampled)		7
	2	8½

21823. Bituminous coal from same mine and bed as No. 21821. Sample cut at face of No. 2 right entry off new main entry March 31, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	2	3½
Clay and rash		1
Coal (sampled)		6
Rash		1
	2	11½

21824. Composite of samples 21821 to 21823, inclusive.

21825. Bituminous coal from Davis Creek (drift) mine of Kentucky-Tennessee Coal Co., half a mile north of Habersham, on Louisville & Nashville Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?).

TENNESSEE—Continued.

Roof is sandy shale and floor is clay. Sample cut at face of No. 3 right entry, 1,500 feet southeast and 300 feet southwest from mouth, March 31, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and blocky (sampled)	1	3
Clay		10
Rash and clay interbedded		9
Clay		11
Coal, bright and blocky (sampled)	2	2½
	5	11½

21826. Bituminous coal from Old Davis Creek (drift) mine. Same bed and operating company as No. 21825. Sample dry; cut at face of No. 5 left entry, 1,650 feet southeast and 250 feet northeast from mouth, March 31, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)		10
Coal, soft and laminated (sampled)		5
Clay		7
Rash and clay interbedded		4
Clay		9
Coal, bright and hard (sampled)	2	4½
	5	3½

21827. Bituminous coal from Red Moon (drift) mine of Red Moon Coal Co., 1½ miles southeast of Morley, on Louisville & Nashville Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample damp; cut at face of No. 3 main south entry, 1,900 feet southwest of mouth, April 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, with thin lenses of coal interbedded	1	3
Coal, massive and brittle (sampled)	2	9
	4	0

21828. Bituminous coal from same mine and bed as No. 21827. Roof is sandstone and floor is clay. Sample damp; cut at face of No. 3 main north entry, 1,800 feet southwest of mouth, April 1, 1915, by F. R. Clark; represents 2 feet 7 inches of clean coal, total thickness of bed.

21829. Bituminous coal from same mine and bed as No. 21827. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 1 right entry, 1,950 feet southwest of mouth, April 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, with thin lenses of coal interbedded	1	3
Coal, bony		1½
Rash and coal interbedded		2
Coal, bright, massive, and brittle (sampled)	2	7½
	4	2

21830. Composite of samples 21827 to 21829, inclusive.

21831. Bituminous coal from Indian Mountain (drift) mine of Proctor Coal Co., 2½ miles west of Jellico, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample dry; cut from rib at mouth of Short Dog entry off No. 3 main entry, 1,000 feet southwest of mouth of No. 3 mine, April 2, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		2
Coal, bright and blocky (sampled)	3	1
	3	3

21832. Bituminous coal from same mine and bed as No. 21831. Sample dry; cut at face of No. 4 left entry off No. 1 main entry, 900 feet southeast of mouth of No. 1 mine, April 2, 1915, by F. R. Clark; represents 3 feet 8 inches of clean, bright, and brittle coal, entire thickness of bed.

21833. Bituminous coal from same mine and bed as No. 21831. Sample dry; cut at face of No. 2 left entry, off No. 2 main entry, 700 feet southeast of mouth of No. 2 mine, April 2, 1915, by F

TENNESSEE—Continued.

Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	2	11
Bone		1
Coal, rashy		3
	3	3

21834. Bituminous coal from same mine and bed as No. 21831. Sample, dry; cut at face of No. 4 entry, off No. 5 main entry, 1,200 feet southeast of mouth of No. 5 mine, April 2, 1915, by F. R. Clark; represents 2 feet 2 inches of coal, entire thickness of bed.

21835. Composite of samples 21832 to 21834, inclusive.

21836. Bituminous coal from Braughton (drift) mine, operated by S. M. Braughton, half a mile east of Jellico, on the Southern Railway and Louisville & Nashville Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample, dry; cut in face of main entry, 1,600 feet south-southeast of mouth, April 2, 1915, by F. R. Clark; represents 1 foot 5 inches of massive, brittle coal, total thickness of bed.

21837. Bituminous coal from same mine and bed as No. 21836. Sample, dry; cut at face of last room on main entry, 1,200 feet southeast of mouth, April 2, 1915, by F. R. Clark; represents 2 feet 2 inches of massive, brittle coal, entire thickness of bed.

21838. Composite of samples 21836 and 21837.

21839. Bituminous coal from Falls Branch (drift) mine of Falls Branch Coal Co., 2¼ miles northwest of Oswego, on Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample, dry; cut from rib at mouth of room No. 1, off No. 49½ entry, 2,500 feet northeast, 550 feet northwest, and 350 feet northeast from mouth, April 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone, coal and rash interbedded		3
Coal, bright and hard (sampled)		10
Bone		2
Coal, bright and hard (sampled)	2	2
	3	5

21840. Bituminous coal from same mine and bed as No. 21839. Sample cut at face of room No. 1 off No. 39 right entry, 2,500 feet northeast, 375 feet southeast, 125 feet northeast, and 100 feet southeast from mouth, April 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		2
Coal, bright and blocky (sampled)	2	11
	3	1

21841. Bituminous coal from same mine and bed as No. 21839. Sample dry; cut at face of No. 59 entry, 1,000 feet northeast, 1,200 feet northwest, and 800 feet northeast from mouth, April 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone and rash		2
Coal, bright and hard (sampled)	3	1
	3	3

21842. Bituminous coal from same mine and bed as No. 21839. Sample dry; cut at face of No. 58 entry, 1,000 feet northeast, 1,550 feet northwest, and 900 feet northeast from mouth, April 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone and rash		2
Coal, bright and hard (sampled)	2	9
	2	11

21843. Composite of samples 21840 to 21842, inclusive.

21853. Bituminous coal from Anthras (drift) mine of Tennessee Jellico Coal Co., half a mile south of Anthras, on Clearfork branch of Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 2 left entry off No. 2

TENNESSEE—Continued.

main entry, 2,450 feet S. 45° E. and 200 feet N. 45° E. from mouth, April 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive, hard, and dull (sampled)	1	5
Coal, lustrous and hard (sampled)	1	6
	2	11

21854. Bituminous coal from same mine and bed as No. 21853. Sample dry; cut in at face of No. 1 left entry off No. 2 main entry, 2,200 feet S. 45° E. and 300 feet N. 45° E. from mouth, April 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		2
Coal, massive, hard, and dull (sampled)	1	3
Coal, lustrous and brittle (sampled)	1	7
	3	0

21855. Bituminous coal from same mine and bed as No. 21853. Sample dry; cut from pillar No. 10 off No. 2 right entry, 400 feet S. 45° E. and 400 feet S. 45° W. from mouth, April 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, massive and hard (sampled)	2	9
	2	10

21856. A composite of samples 21853 to 21855, inclusive.

21871. Bituminous coal from Powhatan (drift) mine of Falls Branch Coal Co., half a mile northwest of Oswego, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 10 entry, 3,100 feet northwest of mouth, April 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1½
Coal, bright and hard (sampled)	1	10
	1	11½

21872. Bituminous coal from same mine and bed as No. 21871. Sample dry; cut at face of room 10 off No. 9 entry, 2,700 feet north-northwest of mouth, April 3, 1915, by F. R. Clark; represents 1 foot 10 inches of hard, brittle coal, entire thickness of bed.

21873. Composite of samples 21871 and 21872.

21924. Bituminous coal from Blue Gem (drift) mine of Blue Gem Coal Co., 1 mile south of Jellico, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample dry; cut at face of Pine Mountain left entry, 160 feet southeast of mouth, April 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and very hard (sampled)	2	2
Rash		1
	2	3

21925. Bituminous coal from same mine and bed as No. 21924. Sample dry; cut at face of Pine Mountain right entry, 200 feet southwest of mouth, April 10, 1915, by F. R. Clark; 2 feet of lustrous, hard, and brittle coal, entire thickness of bed.

21926. Bituminous coal from same mine and bed as No. 21924. Sample dry; cut at face of No. 2 right entry off Crouch Creek entry, 450 feet west of mouth, April 10, 1915, by F. R. Clark; represents 1 foot 6 inches of hard, lustrous coal, entire thickness of bed.

21927. A composite of samples 21924 to 21926, inclusive.

21928. Bituminous coal from Old Italian Blue Gem (drift) mine of Whistle Creek Mining Co., 1½ miles northeast of Newcomb, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample wet; cut at face of Ben Vicar entry off No. 4 right entry, 875 feet east-southeast, 190 feet south-southwest, and 150 feet west-northwest from mouth, April 12, 1915, by

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F. R. Clark. Section of coal bed at point sampled is as follows:

	Ft.	in.
Coal, massive (sampled)		2
Mineral charcoal (sampled)		½
Coal, massive and hard (sampled)	1	3
	1	5½

21929. Bituminous coal from same mine and bed as No. 21928. Sample wet; cut at face of No. 3 left entry off old main entry, 775 feet east-northeast and 800 feet north-northeast from mouth, April 12, 1915, by F. R. Clark; represents 2 feet 1 inch of hard, massive coal, entire thickness of bed.

21930. A composite of samples 21928 and 21929.

21931. Bituminous coal from Washington Blue Gem (drift) mine of Wooldridge Jellico Coal Co., 1½ miles northwest of Newcomb, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample wet; cut at face of No. 6 "break through" off main tunnel entry, 700 feet west-southwest of mouth, April 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)		9
Mineral charcoal and sulphur interbedded		¾
Coal, massive and hard		11
	1	8¾

21932. Bituminous coal from same mine and bed as No. 21931. Sample dry; cut at face of No. 1 left entry, 800 feet west-southwest of mouth, April 13, 1915, by F. R. Clark; represents 1 foot 10 inches of hard massive coal, entire thickness of bed.

21933. A composite of samples 21931 and 21932.

21996. Bituminous coal (weathered) from the Brummitt (drift) mine of New Blue Gem Coal Co., 1½ miles west of Newcomb, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample dry; cut from rib of No. 1 main entry, 100 feet west of mouth, April 14, 1915, by F. R. Clark; represents 1 foot 7 inches of hard massive coal, entire thickness of bed.

21997. Cannel coal from a drift mine of Jellico Cannel Coal Co., 2 miles west of Newcomb, on Southern Railway. Coal bed, no name; Carboniferous age; formation not identified. Roof is sandstone and floor is clay. Sample dry; cut from rib on main entry opposite third left entry 300 feet north-northeast and 720 feet west-northwest from mouth, April 14, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, bituminous		10
Bone		½
Coal, cannel (sampled)	2	1½
Clay		¼
Shale, bituminous		1¾
Coal, cannel (sampled)		7
	3	9

At the time the sample was collected the mine was not in operation and the sample was cut from the rib which had been exposed to the mine air for a considerable time. The coal is probably only slightly weathered.

21998. Bituminous coal (rib sample) from Jameson Blue Gem (drift) mine of H. M. Jones Coal Co., 3 miles south of Jellico, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample wet; cut from rib 150 feet north of mouth of No. 10 main entry April 12, 1915, by F. R. Clark; represents 1 foot 11 inches of hard massive coal, entire thickness of bed.

21999. Bituminous coal from same mine and bed as No. 21998. Sample dry; cut at face of No. 13 main entry, 650 feet south of mouth, April 12, 1915, by F. R. Clark; represents 1 foot 11 inches of hard massive coal, total thickness of bed.

22000. Bituminous coal from small drift mine of F. S. Black, 1½ miles east-south-

TENNESSEE—Continued.

east of Jellico, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample dry; cut at face of main entry, 300 feet north-northeast of mouth, April 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		3
Coal, massive and hard (sampled)	1	9
	2	0

22001. Bituminous coal from Evans (drift) mine of Evans Coal Co., 1½ miles south of Jellico, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Blue Gem, Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample dry; cut at face of room 10 off No. 3 left entry, 300 feet south of mouth, April 10, 1915, by F. R. Clark; represents 1 foot 10 inches of hard, brittle, lustrous coal, entire thickness of bed.

22002. Bituminous coal from same mine and bed as No. 22001. Sample dry; cut from face of room 7 off No. 4 left entry, 600 feet southwest of mouth, April 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, lustrous and hard (sampled)	1	11
	2	0

22003. Composite of samples 22001 and 22002.

22004. Bituminous coal from Marion-Anna (drift) mine of Wooldridge Jellico Coal Co., 3 miles north-northwest of Newcomb, on Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample cut at face of No. 1 right entry, 3,000 feet west of mouth, April 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		4
Coal, bright and brittle (sampled)		4
Coal, dull (sampled)		1½
Coal, bright and hard (sampled)		4½
Coal, rash and bone		4
Clay		4
Coal, massive and hard (sampled)	1	6
	3	4

22005. Bituminous coal from same mine and bed as No. 22004. Sample cut from pillar off T right entry, 3,200 feet west-northwest of mouth, April 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		2
Coal, bright and brittle (sampled)		9
Coal, rashy (sampled)		2
Clay, containing sulphur balls		6
Coal, massive and hard, containing thin films of sulphur (sampled)	1	4
	2	11

22006. Bituminous coal from same mine and bed as No. 22004. Sample dry; cut from pillar off No. 3 main entry, 3,400 feet west-northwest of mouth, April 13, 1915, by F. R. Clark. Section of bed at point sampled is as follws:

	Ft.	in.
Bone		1
Coal, dull and hard (sampled)		10
Rash		2
Clay		2
Rash and coal interbedded		3½
Clay		5
Coal, massive and brittle (sampled)	1	8
	3	7½

22007. Composite of samples 22004 to 22006, inclusive.

22008. Bituminous coal from Zechini (drift) mine of Whistle Creek Mining Co., 2½ miles west of Newcomb, on Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample dry; cut at face of Vaughn entry, 500 feet N. 20° W. of mouth,

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April 14, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	2	1
Clay		9
Coal, impure		3
	3	1

22009. Bituminous coal from same mine and bed as No. 22008. Sample dry; cut at face of main east entry, 400 feet N. 65° W. of mouth, April 14, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		2
Bone		½
Coal, massive and hard (sampled)	1	8
	1	10½

22010. Bituminous coal from same mine and bed as No. 22008. Sample dry; cut at face of main entry, 500 feet N. 55° W. of mouth, April 14, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		2
Bone		1
Coal, lustrous and brittle (sampled)	1	9
Clay		4
Coal, impure		6
	2	10

22011. Composite of samples 22008 to 22010, inclusive.

22012. Bituminous coal from Perkins Branch (drift) mine of Perkins Branch Blue Gem Coal Co., 1½ miles northwest of Elk Valley, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 1 right entry, 700 feet west of mouth, April 15, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and brittle (sampled)	1	0
Coal and thin films of sulphur interbedded (sampled)		1
Coal, massive and brittle (sampled)		6
	1	7

22013. Bituminous coal from same mine and bed as No. 22012. Sample dry; cut at face of No. 2 right entry, 700 feet west-southwest of mouth, April 15, 1915, by F. R. Clark; represents 1 foot 7½ inches of hard, massive coal, entire thickness of bed.

22014. Composite of samples 22012 and 22013.

22015. Bituminous coal from Elkhart (drift) mine of Fox Blue Gem Coal Co., three-fourths of a mile north-northwest of Elk Valley, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 2 left entry, 1,200 feet west-southwest of mouth, April 15, 1915, by F. R. Clark; represents 1 foot 7 inches of hard, massive coal, entire thickness of bed.

22016. Bituminous coal from same mine and bed as No. 22015. Sample cut at face of room 8 off No. 2 left entry, 700 feet west-southwest of mouth, April 15, 1915, by F. R. Clark; represents 1 foot 6 inches of hard, massive coal, entire thickness of bed.

22017. Composite of samples 22015 and 22016.

22018. Bituminous coal from Elk Valley (drift) mine of Elk Valley Blue Gem Coal Co., 1 mile northwest of Elk Valley, on Southern Railway. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of main entry, 900 feet north of mouth, April 15, 1915, by F. R. Clark; represents 1 foot 7 inches of hard, massive coal, entire thickness of bed.

22019. Bituminous coal from same mine and bed as No. 22018. Sample dry; cut at face of mud entry, 300 feet north-northeast of mouth, April 15, 1915, by F. R. Clark; represents 1 foot 5½ inches of hard massive coal, entire thickness of bed.

22020. Composite of samples 22018 and 22019.

22021. Bituminous coal from Rock Springs (drift) mine of Turley Coal Co., 1½ miles west-southwest of Turley, on Southern Railway. Coal bed, Upper

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Dean; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 2 main entry, 2,500 feet west-southwest of mouth, April 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated and soft (sampled)	1	2
Coal, very dull, hard, and bony (sampled)		6
Shale		3
Coal, massive and very hard (sampled)	2	5
	4	4

22022. Bituminous coal from same mine and bed as No. 22021. Sample dry; cut at face of No. 4 right entry, 2,000 feet west of mouth, April 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, containing sulphur bands (sampled)	1	2
Coal, dull, massive, and hard (sampled)		6
Shale		4
Coal, massive and very hard (sampled)	2	4½
	4	4½

22023. Bituminous coal from same mine and bed as No. 22021. Sample wet; cut at face of room 8 off No. 2 left entry, 1,800 feet southwest of mouth, April 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and laminated (sampled)	1	2
Coal, very dull, hard, and bony (sampled)		3
Coal, lustrous and very hard (sampled)		5
Shale		4
Coal, massive, blocky, and hard (sampled)	2	4
	4	6

22024. Composite of samples 22021 to 22023, inclusive.

22025. Bituminous coal from Pee Wee (drift) mine of Block Coal & Coke Co., 1 mile west-southwest of Block, on Southern Railway. Coal bed, Red Ash; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandy shale and floor is shale and clay. Sample dry; cut from rib near face of No. 2 left entry, 350 feet west-southwest of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and brittle (sampled)		7
Coal, locally containing thin films of sulphur (sampled)		½
Coal, bright (sampled)		1¼
Shale, containing sulphur balls		¾
Coal, bright and brittle (sampled)	2	½
	2	10

22026. Bituminous coal from same mine and bed as No. 22025. Sample dry; cut at face of No. 1 right entry, 300 feet north of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bony (sampled)		1
Coal, bright and hard (sampled)		5
Coal, very dull and very hard (sampled)		½
Coal, rashy (sampled)		1½
Coal, lustrous and brittle (sampled)	2	1
Rash		1
	2	10

22027. A composite of samples 22025 and 22026.

22028. Bituminous coal from Monarch (drift) mine of Block Coal & Coke Co., 1 mile west-southwest of Block, on Southern Railway. Coal bed, Monarch or Upper Dean; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is sandy shale and floor is clay. Sample dry; cut at face of room 49 off No. 2 left entry, 1,700 feet south of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and soft (sampled)	1	1
Coal, dull and very hard (sampled)		2
Coal, bright and soft (sampled)		4
Shale		1
Coal, bright and hard (sampled)		4

TENNESSEE—Continued.

	Ft.	in.
Coal, dull and very hard (sampled)		4
Coal, lustrous and hard (sampled).		9
Coal, alternating dull and bright bands (sampled)	1	2
Shale		1
Coal, bright and hard (sampled)..		7
Coal, dull and very hard (sampled)		4
	5	3

22029. Bituminous coal from same mine and bed as No. 22028. Sample dry; cut at face of No. 3 right entry, 1,050 feet northwest of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and soft (sampled)..	1	1
Shale		4
Coal, massive, lustrous, containing soft bands (sampled)	2	11½
Shale	1	3
Coal, lustrous (sampled)		11
	6	6½

22030. Bituminous coal from same mine and bed as No. 22028. Sample dry; cut at face of room 23, near face of No. 2 right entry, 1,050 feet north-northwest of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous, containing thin bands of dull coal (sampled)	1	7
Shale		4
Coal, massive, hard, containing dull bands (sampled)	2	9
Shale	1	2
Coal, lustrous (sampled)		11
	6	9

22031. Bituminous coal from same mine and bed as No. 22028. Sample dry; cut in room neck off No. 1 left entry off No. 1 left cross entry, 2,000 feet south-southeast of mouth, April 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and soft (sampled)..	1	0
Coal, dull and very hard (sampled)		2
Coal, lustrous and soft (sampled)..		4
Shale		3
Coal, massive, hard, and blocky (sampled)	3	0
Sulphur lens		½
Coal, massive and hard (sampled).		6
	5	3½

22032. Composite of samples 22028 to 22031, inclusive.

CLAIBORNE COUNTY.

21844. Bituminous coal from Pruden (drift) mine of Pruden Coal & Coke Co., 1 mile east of Pruden, on Clearfork branch of Southern Railway. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is sandy shale and shale and floor is clay. Sample dry; cut at face of room 4 (left) off No. 7 left entry off No. 3 main entry, 1,900 feet east of mouth, April 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and blocky (sampled).	2	0
Coal, rashy (sampled)		2
Clay		½
Coal, dull and bony (sampled)....		2
Coal, bright, containing thin films of sulphur (sampled)	2	4
Clay		1
Coal, bright (sampled)		5
	5	2½

21845. Bituminous coal from same mine and bed as No. 21844. Sample dry; cut at face of room 9 off No. 17 left entry off No. 1 main entry, 2,100 feet south of mouth, April 5, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		1
Rash		¼
Coal, laminated and impure (sampled)	1	10
Rash		2
Clay and rash interbedded		6
Rash		4
Coal, laminated, containing thin films of sulphur (sampled)	1	10
Rash		4
Coal (sampled)		2½
Shale		1

TENNESSEE—Continued.

	Ft.	in.
Coal (sampled)		2
Shale		6
Coal, massive and hard (sampled)	3	1
	9	2

21846. Bituminous coal from same mine and bed as No. 21844. Sample dry; cut at face of No. 17 right entry off No. 1 main entry, 3,000 feet south of mouth, April 5, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)	2	1
Rash		2
Coal, bright and soft (sampled)		4
Shale		1½
Coal, bright and soft (sampled)		3
Clay, containing sulphur balls		5
Coal, massive and hard (sampled)	3	0
	6	4½

21847. Bituminous coal from same mine and bed as No. 21844. Sample cut at face of room 16 off No. 5 right entry off No. 3 main entry, 1,300 feet south-southeast of mouth, April 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)	1	9
Shale and bands of bone, interbedded		5
Bone and lenses of impure coal, interbedded		3
Coal, bright, containing dull bands of bony coal (sampled)	2	2
Rash		½
Coal, bright (sampled)		2
Shale		10
Coal, massive and hard	2	11
	8	6½

21848. A composite of samples 21844 to 21847, inclusive.

21849. Bituminous coal from King Mountain (drift) mine of Clairfield Jellico Coal Co., three-fourths of a mile east of Clairfield, on Clearfork branch of Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample dry; cut at face of room 3 off No. 3 left entry off No. 1 left entry, 1,000 feet S. 50° E. of mouth, April 7, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, very hard, tough, and dull (sampled)	1	6
Coal, lustrous, hard, and brittle (sampled)	1	7
	3	2

21850. Bituminous coal from same mine and bed as No. 21849. Sample dry; cut at face of room 14 off No. 2 left entry off No. 1 right main entry, 1,850 feet S. 30° W. of mouth, April 7, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and shale		2
Coal, massive and hard, containing thin films of sulphur (sampled)	3	0
Rash		3
	3	5

21851. Bituminous coal from same mine and bed as No. 21849. Sample dry; cut at face of room 4 off No. 1 left entry off No. 1 left main entry, 700 feet S. 25° E. of mouth, April 7, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1½
Coal, dull and hard (sampled)	1	6
Coal, very lustrous and hard (sampled)	1	7
	3	2½

21852. Composite of samples 21849 to 21851, inclusive.

21857. Bituminous coal from High Cliff (drift) mine of High Cliff Coal Co., half a mile south of Pruden, on Clearfork branch of Southern Railway. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is shale and floor is clay. Sample dry; cut at face of main entry, 3,300 feet S. 45° E. of mouth, April 7,

TENNESSEE—Continued.

1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		1
Rash		2
Coal, bright and laminated (sampled)	2	8
Clay, containing sulphur balls		4
Coal, massive and hard (sampled)	2	6
	5	9

21858. Bituminous coal from same mine and bed as No. 21857. Sample dry; cut at face of room 5 off No. 8 right entry, 2,900 feet S. 45° E. and 300 feet S. 45° W. from mouth, April 7, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright		1
Clay		2
Rash		1½
Coal, lustrous and laminated (sampled)	2	4
Coal, rashy (sampled)		½
Coal, bright (sampled)		2
Clay, containing thin bands of coal		8
Coal, massive, containing thin bands of dull coal (sampled)	2	11
	6	6

21859. Bituminous coal from same mine and bed as No. 21857. Sample dry; cut at face of room 6 off No. 7 right entry, 2,530 feet S. 45° E. and 400 feet S. 45° W. from mouth, April 7, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, very dull and hard (sampled)		2
Clay		3
Rash		1
Coal, lustrous and brittle (sampled)	2	0
Coal and rash interbedded		1½
Coal (sampled)		5½
Clay		5
Coal, massive and hard, containing dull bands (sampled)	2	11½
	6	5½

21860. Bituminous coal from same mine and bed as No. 21857. Sample dry; cut at face of room 5 off No. 6 right entry, 2,160 feet S. 45° E. and 350 feet S. 45° W. from mouth, April 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		1½
Clay		3
Bone and lenses of coal interbedded		2
Coal, massive and bright (sampled)	2	2
Shale		1
Coal (sampled)		3
Shale, containing kidneys of sulphur		4
Coal, massive, hard, and blocky (sampled)	2	8
	6	½

21861. A composite of samples 21857 to 21860, inclusive.

21862. Bituminous coal from Buffalo (drift) mine of Campbell Coal Mining Co., three-fourths of a mile south of Eagan, on Clearfork branch of Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and sandy shale and floor is clay. Sample dry; cut at face of No. 9 main entry, 3,250 feet south of mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, very bright and hard (sampled)	2	10½
	3	½

21863. Bituminous coal from same mine and bed as No. 21862. Sample dry; cut at face of No. 10 right entry, 2,400 feet south and 1,050 feet west from mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		½
Coal, massive and hard (sampled)	3	½
	3	1

TENNESSEE—Continued.

21864. Bituminous coal from same mine and bed as No. 21862. Sample dry; cut at face of No. 8 right entry, 2,000 feet south and 1,500 feet west from mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		½
Coal, very bright and very hard (sampled)	3	1
	3	1½

21865. Bituminous coal from same mine and bed as No. 21862. Sample dry; cut at face of No. 6 right entry, 1,500 feet south and 1,600 feet west from mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1½
Coal, massive, bright, and hard (sampled)	3	1
	3	2½

21866. Composite of samples 21862 to 21865, inclusive.

21867. Bituminous coal from Standard (drift) mine of Standard Jellico Coal Co., 1 mile east of Clairfield, on Clearfork branch of Southern Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample dry; cut in room neck 17 off No. 1 C entry, 825 feet N. 5° W. of mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone and rash, interbedded		4
Coal, massive, dull, and hard (sampled)	1	3
Coal, soft and rashy (sampled)		2
Coal, lustrous, hard, and brittle (sampled)	1	6
	3	3

21868. Bituminous coal from same mine and bed as No. 21867. Sample dry; cut at face of room 20 off No. 3 D entry, 2,100 feet N. 15° E. of mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, dull and very hard (sampled)		8
Coal, lustrous and hard (sampled)	2	4
	3	0

21869. Bituminous coal from same mine and bed as No. 21867. Sample dry; cut at face of No. 3 C entry, 1,100 feet N. 30° W. of mouth, April 8, 1915, by F. R. Clark; represents 2 feet 6 inches of bright hard coal, total thickness of bed.

21870. A composite of samples 21867 to 21869, inclusive.

22087. Bituminous coal from mine No. 3 (a drift mine) of Yellow Creek Coal Co., 2,500 feet south-southwest of Bosworth, Ky., on Mingo branch of Louisville & Nashville Railroad. Coal bed, Billygoat; Carboniferous age; formation not identified. Roof is sandy shale and floor is sandstone. Sample dry; cut on chain pillar off No. 2 right entry, 600 feet S. 30° E. of mouth, April 28, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and clay		1
Coal, badly crushed (sampled)	1	4½
Coal, massive, lustrous, and hard	1	5
	2	10½

22088. Bituminous coal from same mine and bed as No. 22087. Sample dry; cut at face of No. 4, right entry, 1,150 feet S. 25° E. of mouth, April 28, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		¾
Coal, lustrous and brittle (sampled)	2	10
	2	10¾

22089. Bituminous coal from same mine and bed as No. 22087. Sample dry; cut at face of main entry, 1,500 feet S. 45° E. of mouth, April 28, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright		1
Coal, impure and bony		1
Coal, lustrous and brittle (sampled)	2	4
	2	6

TENNESSEE—Continued.

22090. Bituminous coal from same mine and bed as No. 22087. Sample dry; cut at face of No. 5, left entry, 1,250 feet S. 70° E. of mouth, April 28, 1915, by F. R. Clark; represents 2 feet 8 inches of lustrous, brittle coal, entire thickness of bed.

22091. A composite of samples 22087 to 22090 inclusive.

22097. Bituminous coal from No. 5 (drift) mine of Mingo Coal & Coke Co., 1,500 feet southeast of Hartranft, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Poplar Lick; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 21, left entry, 3,600 feet S. 45° E. of mouth, April 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and soft (sampled)		5
Bone and sulphur bands interbedded		5
Coal, massive and hard (sampled)	3	4
	4	2

22098. Bituminous coal from same mine and bed as No. 21097. Sample dry; cut at face of No. 11, right entry, 3,200 feet S. 5° W. of mouth, April 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and resinous (sampled)		8
Bone		2½
Coal, very hard and dull (sampled)	1	0
Coal, lustrous and hard (sampled)	2	0
Rash		4
	4	2½

22126. Bituminous coal from same mine and bed as No. 22097. Sample dry; cut at face of No. 19, right entry, 3,700 feet S. 10° E. of mouth, April 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, containing thin bands of sulphur (sampled)		9½
Bone		2½
Coal, very dull and very hard (sampled)		10½
Coal, soft and badly crushed (sampled)		4
Coal, massive and hard (sampled)	2	0
	4	2½

22099. Composite of samples 22097, 22098, and 22126.

22100. Bituminous coal from Sterling (drift) mine of Sterling Coal & Coke Co., half a mile west-southwest of Manring, at terminus of Mingo branch of Louisville & Nashville Railroad. Coal bed, Poplar Lick; Carboniferous age; formation not identified. Roof is sandy shale and sandstone and floor is clay. Sample dry; cut at face of No. 6 left entry off No. 2 face entry, 6,400 feet west and 2,000 feet north from mouth, April 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous, laminated, and rashy (sampled)		9
Coal, bony (sampled)		1
Coal, massive and hard (sampled)	1	0
Coal, locally bony and containing thin streaks of sulphur (sampled)		1
Coal, massive and hard (sampled)	2	8
	4	7

22101. Bituminous coal from same mine and bed as No. 22100. Sample dry; cut at face of No. 2 entry off No. 4 right entry off No. 2 face entry, 5,500 feet west and 2,900 feet north from mouth, April 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, rashy (sampled)		6
Coal, bright and hard (sampled)		11
Coal, very dull and very hard (sampled)		4
Coal, bright, massive, and hard (sampled)	2	6
	4	3

22102. Bituminous coal from same mine and bed as No. 22100. Sample dry; cut at face of room 1 off No. 2 right entry off No. 2 face entry, 4,500 feet west and 2,800

TENNESSEE—Continued.

feet north from mouth, April 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and brittle (sampled)		4
Coal, rashy (sampled)		9
Coal, lustrous and hard (sampled)		8
Coal, dull and very hard (sampled)		8
Coal, massive, bright, and hard (sampled)	1	8
	4	1

22103. Bituminous coal from same mine and bed as No. 22100. Sample dry; cut at face of room No. 1 off No. 3 left entry off No. 2 face entry, 5,600 feet west and 1,400 feet north from mouth, April 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and brittle (sampled)		5
Coal, rashy, high in ash (sampled)		8
Coal, lustrous and brittle (sampled)	1	3
Shale		½
Coal, massive and hard (sampled)	2	8
	5	½

22104. Composite of samples 22100 to 22103, inclusive.

22105. Bituminous coal from No. 2 (drift) mine of Bryson Mountain Coal & Coke Co., 700 feet west of Bryson, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Poplar Lick; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample dry; cut from rib on main entry 500 feet west of mouth April 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive, blocky, and hard (sampled)	3	8
Coal, rashy (sampled)		2
Coal, massive, bright, and hard (sampled)	1	2
	5	0

This mine was not in operation at the time the sample was collected and absolutely fresh coal could not be obtained. The sample is probably slightly weathered.

22106. Bituminous coal from No. 1 (drift) mine of Bryson Mountain Coal & Coke Co., at Bryson, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is shale and sandy shale and floor is clay. Sample dry; cut from stump No. 16 off No. 3 cross entry, 3,400 feet S. 70° W. of mouth, April 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous, laminated, and soft (sampled)	2	2
Rash		3
Shale and sulphur lens interbedded		1
Coal, lustrous and soft (sampled)	2	0
Sulphur bands		½
Coal, bright (sampled)		1½
Rash		1
	4	9

22107. Bituminous coal from same mine and bed as No. 22106. Sample dry; cut from chain pillar off No. 1 cross entry, 2,600 feet S. 45° W. of mouth, April 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and soft (sampled)	2	4
Rash and lenses of coal interbedded		5
Shale and bands of sulphur interbedded		4
Coal and bands of sulphur interbedded		1
Coal, lustrous and banded (sampled)	2	1½
Clay		1
Coal, bright (sampled)		1½
	5	6

22108. Bituminous coal from same mine and bed as No. 22106. Sample dry; cut from chain pillar off No. 5 cross entry, 3,800 feet S. 85° W. of mouth, April 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay		5
Coal, massive, but badly crushed (sampled)	1	10½

TENNESSEE—Continued.

	Ft.	in.
Clay and rash interbedded		3
Coal, bright, but badly crushed (sampled)		7
Shale		1
Coal, bright, but crushed (sampled)		11
Shale and rash		½
Coal, rashy and badly crushed (sampled)		6½
Shale and rash		1½
Coal, bright and hard (sampled)		2
Rash		½
	5	½

22109. Composite of samples 22106 to 22108, inclusive.

22110. Bituminous coal from No. 4 (drift) mine of Fork Ridge Coal & Coke Co., 1½ miles southwest of Fork Ridge, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Poplar Lick; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample cut at face of No. 1 right entry off No. 1 face entry, 2,400 feet west, 350 feet north, and 200 feet east from mouth, April 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and soft (sampled)		8½
Bone		1
Coal, bright and soft (sampled)		4
Bone		8
Coal, bony (sampled)		6
Coal, massive, bright and brittle (sampled)	1	8
	3	11½

22111. Bituminous coal from same mine and bed as No. 22110. Sample cut at face of main entry, 2,500 feet west of mouth, April 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive (sampled)	1	6½
Bone		3½
Coal, massive, hard, and brittle (sampled)	1	10½
	3	8½

22112. Bituminous coal from same mine and bed as No. 22110. Sample cut at face of No. 2 cross entry, 2,400 feet west and 600 feet south from mouth, April 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and soft (sampled)		8
Bone		2
Coal, bright and soft (sampled)		5
Bone		7
Coal, massive and hard (sampled)	2	1
Rash		½
	3	11½

22113. Composite of samples 22110 to 22112, inclusive.

22114. Bituminous coal from No. 1 (drift) mine of Fork Ridge Coal & Coke Co., five-eighths of a mile southwest of Fork Ridge, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample dry; cut at face of room 17 off No. 1 right entry, 9,200 feet S. 45° E. of mouth, April 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and laminated (sampled)	2	2
Shale and rash interbedded		3
Coal, lustrous and blocky (sampled)	2	1
	4	6

22115. Bituminous coal from same mine and bed as No. 22114. Sample dry; cut at face of room 11 off No. 2 right entry, 8,900 feet S. 43° E. of mouth, April 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)	1	11½
Shale, rash, and sulphur kidneys, interbedded		2½
Coal, laminated (sampled)	2	1½
	4	3½

22116. Bituminous coal from same mine and bed as No. 22114. Sample dry; cut in face of room 11 off No. 3 left entry,

TENNESSEE—Continued.

8,850 feet S. 48° E. of mouth, April 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled).		10
Coal, laminated and lustrous (sampled)	1	6
Shale and rash interbedded		1½
Coal, lustrous and laminated (sampled)	2	5
	4	10½

22117. Bituminous coal from same mine and bed as No. 22114. Sample dry; cut at face of room 15 off No. 4 left entry, 9,300 feet S. 52° E. of mouth, April 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	2	2
Shale, rash, and sulphur interbedded		2
Coal, laminated, containing bands of mineral charcoal (sampled)	2	2
	4	6

22118. Composite of samples 22114 to 22117, inclusive.

22119. Bituminous coal from Sandstone Parting (drift) mine of Reliance Coal & Coke Co., 900 feet west of Hartranft, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Sandstone Parting; Carboniferous age; formation not identified. Roof is sandstone and floor is shale. Sample wet; cut from rib near face of No. 1 left entry, 500 feet S. 85° W. of mouth, April 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, splintlike (sampled)		1½
Shale		2
Coal, blocky (sampled)		2½
Shale and clay interbedded		11
Coal, massive, blocky, and very hard (sampled)	2	11
	4	4

This mine was not in operation when the sample was taken and therefore fresh coal could not be obtained. The sample is probably slightly weathered.

22120. Bituminous coal from No. 2 (drift) mine of Reliance Coal & Coke Co., at Hartranft, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample dry; cut from barrier pillar off the main air course, 2,700 feet S. 40° W. of mouth, April 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and banded (sampled)	2	0
Rash		2
Shale and rash interbedded		6
Coal, lustrous (sampled)	1	6
Clay and bands of rash, interbedded		7
Coal, lustrous and hard (sampled).		3
	5	0

22121. Bituminous coal from same mine and bed as No. 22120. Sample dry; cut from pillar No. 30 off No. 27 right entry, 1,950 feet S. 25° W. of mouth, April 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and banded (sampled)	1	11
Shale and bands of rash interbedded		5
Coal, lustrous and bedded (sampled)	1	5½
Shale and rash interbedded		4½
Coal, lustrous and hard (sampled).		5
	4	7

22122. Bituminous coal from No. 1 (drift) mine of Reliance Coal & Coke Co., at Hartranft, on Mingo branch of Louisville & Nashville Railroad. Coal bed, Mingo; Carboniferous age; formation not identified. Roof is sandy shale and sandstone and floor is clay. Sample dry; cut at new side track off No. 2 left entry, 500 feet N. 65° W. of mouth, April 24, 1915, by

TENNESSEE—Continued.

F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	2	2
Rash and lenses of coal interbedded		2
Shale and rash, interbedded		9
Coal, lustrous and badly crushed (sampled)	1	4
Shale and clay, interbedded		4
Coal, bright (sampled)		4
	5	1

22123. Bituminous coal from same mine and bed as No. 22122. Sample dry; cut in mine in room No. 1 off No. 3 left entry, 750 feet N. 70° W. of mouth, April 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and bedded (sampled)	1	6
Coal, rashy (sampled)		4
Shale and rash interbedded	1	6
Coal, massive and lustrous (sampled)	1	4
Shale and rash interbedded		6
Coal, bright and hard (sampled)		3
Rash		1
	5	6

22124. Composite of samples 22120 to 22123, inclusive.

FENTRESS COUNTY.

20982. Bituminous coal from Highland No. 2 (drift) mine of Highland Coal & Lumber Co., 1½ miles north of Highland Junction, on Crawford branch of Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Lee formation. Roof and floor are sandstone. Sample damp; cut at face of main entry, 1,350 feet N. 41° E. of mouth, February 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	0
Sulphur kidney		½
Coal (sampled)	3	2
	4	2½

20983. Bituminous coal from same mine and bed as No. 20982. Sample dry; cut at face of No. 2 right entry, 900 feet northeast of mouth, February 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		9
Bone		2½
Coal (sampled)	2	8
	3	7½

20984. Bituminous coal from same mine and bed as No. 20982. Sample dry; cut at face of No. 3 right entry, 1,300 feet east of mouth, February 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		10
Coal, containing thin lenses of sulphur (sampled)		6
Coal, massive and hard (sampled)	3	½
Clay		1
	4	5½

20985. Composite of samples 20982 to 20984, inclusive.

20986. Bituminous coal from same mine and bed as No. 20982. Sample wet and coal possibly slightly weathered; cut near mouth of second left entry, 1,000 feet N. 41° E. of mouth, April 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		5½
Sulphur kidney		1
Coal (sampled)		4
Sulphur kidney		2½
Coal (sampled)	3	½
	4	1½

20987. Bituminous coal from Davidson (drift) mine of Davidson Coal Co., 1⅝ miles north of Highland Junction, on Crawford branch of Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Lee formation. Roof and floor are sandstone. Sample damp; cut at face of main entry, 200 feet northeast of mouth of new opening, February 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

TENNESSEE—Continued.

	Ft.	in.
Coal and thin bands of shale interbedded		1
Sulphur kidney		1½
Coal (sampled)		6½
Coal, containing thin lenses of sulphur (sampled)		7
Sulphur kidney		1
Coal (sampled)	2	11½
	4	4½

20988. Bituminous coal from same mine and bed as No. 20987. Sample damp; cut at face of cross entry 1,000 feet north-northeast of mouth of old opening, February 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing thin lenses of shale		1
Coal, massive (sampled)		10
Coal, soft, containing sulphur balls (sampled)		3
Sulphur kidney		1½
Coal (sampled)		4
Sulphur kidney		½
Coal, massive (sampled)	2	6
	4	2

20989. Composite of samples 20987 and 20988.

GRUNDY COUNTY.

22359. Bituminous coal from Reed Hill No. 1 (drift) mine of Tennessee Consolidated Coal Co., 1½ miles east of Tracy City, on Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample dry; cut in room off main entry 2,400 feet south of mouth May 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, glossy and hard (sampled)	2	8½
Rash		4
	3	½

22360. Bituminous coal from Reed Hill No. 2 (drift) mine of Tennessee Consolidated Coal Co., 2 miles east of Tracy City. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample damp; cut in mine at face of Sitz opening, near face of old No. 7 in old Reed Hill mine, 1,300 feet N. 75° W. of mouth, May 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing thin bands of sulphur		3
Coal, massive and hard (sampled)	3	8
	3	11

22361. Bituminous coal from East Fork (drift) mine of Tennessee Consolidated Coal Co., 1¼ miles northeast of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample cut in room off No. 2 right entry off No. 1 main entry, 1,600 feet S. 16° W. of mouth, May 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, soft, badly crushed and contorted (sampled)	2	10
	3	0

22362. Bituminous coal from Rattlesnake (drift) mine of Tennessee Consolidated Coal Co., 1¾ miles northeast of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample damp; cut at face of crosscut off old Rattlesnake entry, 2,100 feet N. 10° W. of mouth, May 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay		1
Coal, bedded (sampled)	2	10
	2	11

22363. Bituminous coal from East Staub (drift) mine of Tennessee Consolidated Coal Co., 1¼ miles north-northeast of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample cut near No. 1 right entry off Campbell entry, 4,600 feet N. 20° E. of mouth, May 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay, soft		1
Coal, bedded and hard (sampled)	4	4
	4	5

TENNESSEE—Continued.

22364. A composite of samples 22359 to 22363, inclusive.

22371. Bituminous coal from Old Staub (drift) mine of Tennessee Consolidated Coal Co., 1 mile east of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample dry; cut at face of Jerry Downing entry off old main entry, 5,850 feet N. 20° W. of mouth of old No. 1, May 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay, soft		2
Coal, bedded and badly crushed and contorted (sampled)	3	8
	3	10

22403. Bituminous coal from West Ramsey (drift) mine of Tennessee Consolidated Coal Co., 2½ miles west of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample cut near face of Saunders entry, off old N. C. main entry, 1,850 feet S. 60° W. of mine mouth near old Ramsey tipple, May 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay		1
Coal, bedded and badly contorted (sampled)	3	8
	3	9

22404. Bituminous coal from Old Ramsey (drift) mine of Tennessee Consolidated Coal Co., 2½ miles north-northwest of Tracy City. Coal bed, Sewanee. Roof and floor are shale. Sample dry; cut near No. 11 right entry off T. C. I. main entry, 2,600 feet N. 45° E. of mine mouth near old Ramsey tipple, May 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, glossy and bedded (sampled)	4	8
	4	10

22405. Composite of samples 22403 and 22404.

22379. Bituminous coal (weathered) from prospect pit of Tennessee Consolidated Coal Co., 11.4 miles N. 40° E. of Coalmont, at terminus of Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee. Roof is sandstone and floor is shale. Sample damp; cut at face of entry 60 feet east of mouth of prospect, near bottom of main branch of Mill Creek, May 22, 1915, by F. R. Clark; represents 4 feet of hard, massive coal the entire thickness of bed.

22380. Bituminous coal (weathered) from prospect pit on west side of Mill Creek not far from the pit where sample 22379 was taken. Coal bed, Sewanee. Roof is sandstone and floor is shale and clay. Sample, wet; cut at face of entry 50 feet south of mouth, May 22, 1915, by F. R. Clark; represents 3 feet 7 inches of hard, massive, bright coal, entire thickness of bed.

22381. Bituminous coal (weathered) from prospect pit on east side of Mill Creek near pit where sample 22379 was taken. Coal bed, Sewanee. Roof and floor are shale. Sample cut at face of entry 100 feet east of mouth, May 22, 1915, by F. R. Clark; represents 4 feet 2 inches of hard, massive, brilliant coal, entire thickness of bed.

22382. Composite of samples 22379 to 22381, inclusive.

22372. Bituminous coal (rib weathered) from Old Clouse Hill (drift) mine of Sewanee Fuel & Iron Co., 3½ miles west of Tracy City, on Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee. Roof is shale and floor is shale and clay. Sample dry; cut in room 200 feet east of mouth of new opening at southwest corner of Clouse Hill, May 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		½
Shale, carbonaceous		2
Clay		3
Coal, bedded and badly contorted (sampled)	3	4
	3	9½

22373. Bituminous coal from Flanagan (drift) mine of Flat Branch Coal Co., 2 miles southeast of Coalmont, at terminus

TENNESSEE—Continued.

of Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee. Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample dry; cut near face of main entry, 700 feet east and 300 feet south from mouth, May 21, 1915, by F. R. Clark; represents 2 feet 9 inches of laminated and badly crushed coal, entire thickness of bed.

22374. Bituminous coal from the Coalmont S Old Hill (drift) mine of Sewanee Fuel & Iron Co., 2½ miles south-southeast of Coalmont. Coal bed, Sewanee. Roof is shale and floor is sandy shale. Sample dry; cut at face of main entry, 2,380 feet S. 56° 30′ W. of mouth, May 21, 1915, by F. R. Clark; represents 4 feet 11 inches of laminated, glossy coal, entire thickness of bed.

22375. Bituminous coal from Coalmont S New Hill (drift) mine of Sewanee Fuel & Iron Co., 2½ miles south of Coalmont. Coal bed, Sewanee. Roof and floor are shale. Sample dry; cut at face of No. 1 right entry off main entry, 1,063 feet S. 75° W. of mouth, May 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, carbonaceous		6
Coal, glossy, laminated, and contorted (sampled)	3	0
	3	6

22383. Bituminous coal from Coalmont I (drift) mine of Sewanee Fuel & Iron Co., ½ mile N. 15° W. of Coalmont. Coal bed, Sewanee. Roof and floor are shale. Sample damp; cut at face of room 11 off No. 2 left entry, 1,140 feet N. 37° W. and 500 feet S. 55° W. from mouth, May 21, 1915, by F. R. Clark; represents 3 feet of laminated and contorted coal containing thin bands of mineral charcoal, total thickness of bed.

22384. Bituminous coal from Coalmont E (drift) mine of Sewanee Fuel & Iron Co., half a mile N. 15° W. of Coalmont. Coal bed, Sewanee. Roof is shale and floor is clay. Sample damp; cut at face of main entry, 500 feet east of mouth, May 21, 1915, by F. R. Clark; represents 4 feet 2½ inches of laminated and badly contorted coal, entire thickness of bed.

22385. Bituminous coal from Coalmont New A (drift) mine of Sewanee Fuel & Iron Co., a quarter of a mile southeast of Coalmont. Coal bed, Sewanee. Roof and floor are shale. Sample cut in room neck off main entry, 600 feet northeast of mouth, May 21, 1915, by F. R. Clark; represents 2 feet 7 inches of hard laminated glossy coal, entire thickness of bed.

22386. Bituminous coal from Coalmont Old A (drift) mine of Sewanee Fuel & Iron Co., half a mile southeast of Coalmont. Coal bed, Sewanee. Roof is shale and floor is clay. Sample dry; cut in room neck off west main entry, 300 feet east of mouth, May 21, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, soft and laminated (sampled)	2	3
	2	4

22387. Composite of samples 22383 to 22386, inclusive.

HAMILTON COUNTY.

22160. Bituminous coal from Soddy No. 1 (drift) mine of Durham Coal & Iron Co., 1½ miles west of Rathburn, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Soddy; Carboniferous (Pennsylvanian) age; "Walden sandstone"(?). Roof is sandy shale and sandstone and floor is shale and clay. Sample dry; cut at face of room 43 off No. 5 right entry off new haulage way, 8,900 feet S. 75° W. of mouth, May 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		½
Coal, steel-gray and hard (sampled)	2	8
Rash		1
	2	9½

22161. Bituminous coal from same mine and bed as No. 22160. Sample dry; cut in face of room 3 off No. 11 right entry off new haulage way, 9,300 feet S. 65° W. of mouth, May 3, 1915, by F. R. Clark.

TENNESSEE—Continued.

Section of bed at point sampled is as follows:

	Ft.	in.
Coal, steel-gray and hard (sampled)	2	
Coal, laminated (sampled)		3
Bone		2
	2	5

22162. Bituminous coal from same mine and bed as No. 22160. Sample dry; cut in face of No. 14 right entry off new main entry, 7,000 feet N. 85° W. of mouth, May 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, steel-gray and hard (sampled)	2	0
Coal, laminated and bright (sampled)		4
	2	4

22163. Bituminous coal from same mine and bed as No. 22160. Sample dry; cut in face of room 1 off No. 17 right off main entry, 8,200 feet west of mouth, May 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone		1
Coal, steel-gray, hard, and brittle (sampled)	2	4
Rash and coal lenses interbedded		8
	3	1

22164. Composite of samples 22160 to 22163, inclusive.

22187. Bituminous coal from Sheephead (slope) mine of Durham Coal & Iron Co., 1½ miles southwest of Rathburn, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Soddy; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is sandy shale and floor is shale. Sample dry; cut in face of room 3 off new slope, 400 feet N. 10° W. of mouth, May 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, steel-gray and hard (sampled)	2	0
Coal, laminated (sampled)		4
	2	4

22188. Bituminous coal from same mine and bed as No. 22187. Sample dry; cut at face of room 6 off back entry, 350 feet S. 40° W. of mouth, May 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, steel-gray and hard (sampled)	1	5½
Coal, lustrous and hard (sampled)		5
Coal, soft and laminated (sampled)		11
	2	9½

22189. Composite of samples 22187 and 22188.

22190. Bituminous coal from Old Bunker (drift) mine of Durham Coal & Iron Co., 1½ miles southwest of Rathburn, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Soddy; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is sandstone and floor is clay. Sample dry; cut at face of room 5 off main entry, 500 feet N. 80° W. of mouth, May 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and soft (sampled)		7
Coal, steel-gray and hard (sampled)	1	11
Coal, laminated (sampled)		3
	2	9

22211. Bituminous coal from Furman (drift) mine of Durham Coal & Iron Co., three-fourths of a mile west of Rathburn, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Soddy; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is sandy shale and floor is shale and sandstone. Sample dry; cut in mine at face of Jones's place, 650 feet N. 15° W. of mouth, May 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and clay interbedded		2
Coal, laminated, with thin bands of mineral charcoal (sampled)	1	11
Coal, rashy (sampled)		2
	2	3

22212. Bituminous coal from same mine and bed as No. 22211. Sample dry; cut at face of room 4 off No. 1 right entry, 700 feet N. 10° W. of mouth, May 4, 1915,

TENNESSEE—Continued.

by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		1
Coal, laminated and soft (sampled).		2
Coal, steel-gray and hard (sampled).	1	3
	1	6

22213. Composite of samples 22211 and 22212.

22248. Bituminous coal from Big Soddy (drift) mine of Durham Coal & Iron Co., 2¼ miles northwest of Rathburn, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Soddy; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is sandy shale and floor is shale. Sample dry; cut in room 8 off main entry, 1,200 feet N. 25° E. of mouth, May 5, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, laminated and soft (sampled).	3	8
	3	10

22243. Bituminous coal from Montlake (drift) mine of Montlake Coal Co., 2½ miles northwest of Montlake, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, No. 10; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is shale. Sample wet; cut at face of No. 3 crosscut, 1,400 feet N. 30° E. of mouth, May 6, 1915, by F. R. Clark; represents 2 feet 5 inches of hard, lustrous coal, total thickness of bed.

22244. Bituminous coal from same mine and bed as No. 22243. Sample damp; cut at face of No. 11 cross entry, 2,850 feet N. 32° E. of mouth, May 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bony		2
Coal, massive and brittle (sampled)	3	2
	3	4

22245. Bituminous coal from same mine and bed as No. 22243. Sample dry; cut at face of No. 11 cross entry right, 2,700 feet N. 20° E. of mouth, May 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale and bands of bone interbedded		3
Coal, bright, laminated, and soft (sampled)		4
Coal, massive and hard (sampled).	2	9
	3	4

22246. Composite of samples 22243 to 22245.

22247. Bituminous coal from Montlake No. 4 (drift) mine of Montlake Coal Co., 2¾ miles northwest of Montlake station, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, not identified; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample damp; cut at face of No. 1 right entry, 185 feet N. 4° E. and 415 feet S. 86° E. from mouth, May 6, 1915, by F. R. Clark; represents 2 feet 10 inches of soft and badly crushed coal, the entire thickness of the bed.

22249. Bituminous coal from Wagon (drift) mine of J. C. Abel, three-fourths of a mile northwest of Daisy, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, not identified; Carboniferous (Pennsylvanian) age; Lookout sandstone (?). Roof is sandy shale and floor is clay. Sample wet; cut at face of room 2 off main entry, 350 feet north-northeast of mouth, May 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, containing lenses of sulphur		6
Coal, steel-gray and hard (sampled)	1	4
	1	10

MARION COUNTY.

22230. Bituminous coal from Battle Creek No. 4 (drift) mine of Battle Creek Coal & Coke Co., 1½ miles north of Orme, terminus of branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Battle Creek; Carboniferous (Pennsylvanian) age; Lookout sandstone (?). Roof is sandy shale and floor is shale and clay. Sample dry; cut from pillar off No. 5 right entry, 1,600 feet north and 750 feet east from mouth, May 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, very hard and massive (sampled)	1	5
Rash		1½
Coal, laminated and soft (sampled)	3	7½
	5	2

22231. Bituminous coal from Battle Creek No. 3 (drift) mine of Battle Creek Coal & Coke Co., 1½ miles north of Orme. Coal bed, Battle Creek. Sample dry; cut from pillar off Collins entry, 1,550 feet west of mouth, May 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, very hard, massive, and bright (sampled)	2	0
Rash		2
Coal, lustrous and hard (sampled)	1	8
Rash		5
Coal, very bright and soft (sampled)	1	1
	5	4

22232. Bituminous coal from Battle Creek No. 5 mine (drift) of Battle Creek Coal & Coke Co., 2¼ miles north-northwest of Orme. Coal bed, Battle Creek. Roof and floor are shale. Sample dry; cut in main entry 60 feet east of mouth, May 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, very hard, bright, and massive (sampled)	3	6
Rash		4
Coal, lustrous, laminated, and hard (sampled)	2	4
Rash and impure coal intimately mixed	3	2
	9	4

22233. Bituminous coal from same mine and bed as No. 22230. Sample dry; cut from pillar at end of No. 16 left entry, 2,500 feet north and 1,500 feet west from mouth, May 11, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, very bright, hard, and contorted (sampled)	3	4
Rash		2
Coal, bright and hard (sampled)	2	2
Rash		4
Coal, very bright and contorted (sampled)		7
Rash		3
	6	10

22234. Composite of samples 22230 to 22233, inclusive.

22235. Bituminous coal from No. 1 (drift) mine of New Etna Coal Co., 7 miles northwest of Whiteside, on Nashville, Chattanooga & St. Louis Railway. Coal bed, Kelley; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample dry; cut at face of No. 4 cross entry, 3,000 feet northwest of mouth, May 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous, massive, cubical structure (sampled)	1	9
Coal, laminated (sampled)	1	0
	2	9

22236. Bituminous coal from same mine and bed as No. 22235. Sample dry; cut at face of No. 7 cross entry, 2,000 feet northeast of mouth, May 10, 1915, by F. R. Clark. Section of bed at point of sampling is as follows:

	Ft.	in.
Coal, massive (sampled)	1	6
Coal, laminated (sampled)	1	0
	2	6

22237. Bituminous coal from No. 2 (drift) mine of New Etna Coal Co., 7 miles northwest of Whiteside. Coal bed, Kelley; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample damp; cut at face of No. 1 left entry, 1,000 feet southwest of mouth, May 10, 1915, by F. R. Clark; represents 2 feet 6 inches of lustrous jet-black coal, the entire thickness of the bed.

TENNESSEE—Continued.

22238. A composite of samples 22235 to 22237, inclusive.

22251. Bituminous coal from Old Etna No. 1 (drift) mine of Castle Rock Coal & Coke Co., 1⅛ miles west of Whiteside, on Nashville, Chattanooga & St. Louis Railway. Coal bed, Old Etna; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample wet; cut at face of main entry, 165 feet west of mouth, May 8, 1915, by F. R. Clark; represents 2 feet 1 inch of hard, lustrous coal, entire thickness of the bed.

22252. Bituminous coal from Old Etna No. 2 (drift) mine of Castle Rock Coal & Coke Co. Location of mine about the same as No. 22251. Coal bed, Old Etna. Sample wet; cut at face of main entry, 200 feet south-southwest of mouth, May 8, 1915, by F. R. Clark; represents 1 foot 11 inches of hard bright coal, the total thickness of the bed.

22253. Composite of samples 22251 and 22252.

22254. Bituminous coal from Castle Rock (drift) mine of Castle Rock Coal & Coke Co., 1 mile west of Whiteside, on Nashville, Chattanooga & St. Louis Railway. Coal bed, Castle Rock; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample wet; cut at face of main entry, about 200 feet south of mouth, May 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone and sulphur		1
Coal, very bright and hard (sampled)		10½
Coal, laminated (sampled)		7
Rash		1½
Coal, lustrous and soft (sampled)	2	1
	3	9

22255. Bituminous coal from same mine and bed as No. 22254. Sample damp; cut at face of No. 1 right entry, 175 feet S. 20° W. of mouth, May 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, soft and laminated (sampled)	2	0
Coal, rashy (sampled)		4
Rash		3
	2	7

22256. A composite of samples 22254 and 22255.

22257. Bituminous coal from Clements (drift) prospect of Tennessee River Coal & Coke Co., about 1 mile southwest of Whiteside, on Nashville, Chattanooga & St. Louis Railway. Coal bed, Castle Rock; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample damp and slightly weathered; cut from rib of main entry, 100 feet southwest of mouth, May 8, 1915, by F. R. Clark; represents 3 feet 4 inches of hard, massive coal, entire thickness of bed.

22258. Bituminous coal from Bessie (drift) prospect of Tennessee River Coal & Coke Co., 1 mile southwest of Whiteside, on Nashville, Chattanooga & St. Louis Railway. Coal bed, Old Etna; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample dry and weathered; cut from rib in main entry, 400 feet south of mouth, May 8, 1915, by F. R. Clark; represents 2 feet ½ inch of hard, lustrous coal, entire thickness of bed.

22267. Bituminous coal from Whitwell No. 1 (drift) mine of Tennessee Coal, Iron & Railway Co., 1 mile southwest of Whitwell, on Pikeville branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample dry; cut in face of No. 23 south entry, 5,500 feet S. 21° W. of mouth, May 15, 1915, by F. R. Clark; represents 3 feet 4½ inches of hard massive coal, entire thickness of bed.

22268. Bituminous coal from Whitwell No. 5 (drift) mine of Tennessee Coal, Iron & Railway Co., 1¾ miles northwest of Whitwell, on Pikeville branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone."

TENNESSEE—Continued.

Roof and floor are shale. Sample dry; cut at face of No. 7 north entry off main haulage way, 1,150 feet N. 39° E. of mouth, May 15, 1915, by F. R. Clark; represents 3 feet 5 inches of very hard, massive coal, total thickness of bed.

22269. Bituminous coal from same mine and bed as No. 22268. Sample dry; cut at face of main slope entry, 500 feet north and 2,750 feet N. 21° E. from mouth of main haulage way, May 15, 1915, by F. R. Clark; represents 3 feet 3 inches of hard, bedded coal, total thickness of bed.

22270. Bituminous coal from same mine and bed as No. 22268. Sample dry; cut at face of No. 4 north entry off main haulage way, 1,850 feet N. 39° E. of mouth, May 15, 1915, by F. R. Clark; represents 3 feet 3 inches of extra hard, massive coal, total thickness of bed.

22271. Composite of samples 22267 to 22270, inclusive.

22370. Bituminous coal from Long Ridge (drift) mine of Tennessee Consolidated Coal Co., 7 miles east of Tracy City, on Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is shale and floor is clay. Sample damp and slightly weathered; cut at face of main entry, 250 feet S. 45° E. of mouth, May 18, 1915, by F. R. Clark; represents 3 feet 3 inches of hard, massive coal, entire thickness of bed.

22398. Bituminous coal from Pryor Ridge No. 1 (drift) mine of Tennessee Consolidated Coal Co., 5½ miles east of Tracy City, on Tracy City branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are shale. Sample dry; cut at face of room 6 off Thompson entry off left main entry, 1,200 feet N. 10° E. of mouth, May 18, 1915, by F. R. Clark; represents 3 feet 6 inches of soft, glossy coal, entire thickness of bed.

22399. Bituminous coal from same mine and bed as No. 22398. Sample dry; cut at face of No. 4 right entry off No. 5 right entry off left main entry, 2,700 feet east of mouth, May 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay, soft		½
Coal, soft and laminated (sampled)		8
Coal, massive and hard (sampled)	4	0
	4	8½

22400. Bituminous coal from same mine and bed as No. 22398. Sample dry; cut at face of No. 5 right entry off right main entry, 1,800 feet N. 45° W. of mouth, May 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)	3	11½
Rash		½
	4	0

22401. Bituminous coal from same mine and bed as No. 22398. Sample dry; cut from stump No. 20 off No. 5 left entry off right main entry, 1,900 feet S. 80° W. of mouth, May 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		3
Mineral charcoal (sampled)		1
Coal, laminated (sampled)		6
Coal, massive and hard (sampled)	2	0
Coal, soft and laminated (sampled)	1	0
Coal, massive and very hard (sampled)	1	3
	5	1

22402. Composite of samples 22398 to 22401, inclusive.

MORGAN COUNTY.

21083. Bituminous coal (weathered) from Frozen Head (drift) mine, formerly operated by State of Tennessee, 1½ miles north of Petros, at terminus of Harriman & Northeastern Railroad. Coal bed, Frozen Head; Carboniferous (Pennsylvanian) age; Scott shale (?). Roof is shale and floor is fire clay. Sample dry and slightly weathered; cut from rib on main

TENNESSEE—Continued.

entry, 900 feet north of mouth, February 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)		6
Clay and rash interbedded		2
Coal, bright and laminated (sampled)	1	2
Coal, dull, very hard, and splint-like (sampled)		6
Coal, massive, bright, and very hard (sampled)	1	0
Coal, rashy (sampled)		1
Clay and coal lenses interbedded		1½
Rash and coal lenses interbedded		4
Clay		1
Coal, bright and hard		4
	4	3½

21084. Bituminous coal from Little Brushy (drift) mine of Little Brushy Coal Co., half a mile southwest of Stephens, on Harriman & Northeastern Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is sandstone. Sample wet; cut at mouth of room 12 off No. 1 entry, 2,600 feet S. 43° W. of mouth, February 20, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, with thin bands of sulphur (sampled)	1	1
Coal, bright and slightly laminated (sampled)	1	7½
	2	8½

21085. Bituminous coal from same mine and bed as No. 21084. Sample damp; cut from face of dip entry, 2,600 feet S. 43° W. of mouth, February 20, 1915, by F. R. Clark; represents 2 feet 11 inches of bedded coal, locally containing thin bands of sulphur, entire thickness of bed.

21086. Bituminous coal from same mine and bed as No. 21084. Sample wet; cut in mouth of room 4 off main entry of new opening, 2,650 feet S. 43° W. of mouth of old opening, February 20, 1915, by F. R. Clark; represents 2 feet 10 inches of bedded coal, containing thin lenses of sulphur, entire thickness of bed.

21087. Composite of samples 21084 to 21086, inclusive.

21088. Bituminous coal from the Petros No. 5 (drift) mine of Petros Coal Mining Co., 1 mile east of Petros, at terminus of Harriman & Northeastern Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is shale. Sample dry; cut at face of No. 2 right entry, 2,000 feet east-southeast of mouth, February 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		6
Coal, rashy (sampled)		1
Coal, massive (sampled)		6¾
Sulphur kidney		¼
Coal, massive (sampled)	1	5
	2	7

21089. Bituminous coal from same mine and bed as No. 21088. Sample dry; cut at face of No. 3 left entry, 2,500 feet north of mouth, February 19, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)	1	0
Coal, massive and hard (sampled)	1	4
Coal, rashy (sampled)		1
Coal, massive and hard (sampled)	1	1
	3	6

21090. Bituminous coal from same mine and bed as No. 21088. Sample dry; cut at face of No. 4 entry, 2,500 feet north-northeast of mouth, February 19, 1915, by F. R. Clark; represents 2 feet 4 inches of bedded coal, containing thin lenses of sulphur, total thickness of bed.

21091. A composite of samples 21088 to 21090, inclusive.

21092. Bituminous coal from State No. 3 (drift) mine, operated by State of Tennessee, 1 mile north of Petros, at terminus of Harriman & Northeastern Railroad. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and sandstone and floor is clay. Sample dry; cut at face of No.

TENNESSEE—Continued.

cross entry, 3,500 feet N. 55° W. of main entry, February 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, containing thin lenses of sulphur (sampled)		9
Mineral charcoal (sampled)		1
Coal, massive and hard, locally containing thin streaks of mineral charcoal (sampled)	1	10
Rash		2
	2	10

21093. Bituminous coal from same mine and bed as No. 21092. Sample dry; cut at face of No. 9 cross entry, 3,800 feet N. 55° W. of main entry, February 18, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)		1¾
Mineral charcoal (sampled)		1
Coal, laminated (sampled)		6¼
Mineral charcoal (sampled)		2
Coal, massive (sampled)	1	5
Coal, containing thin lenses of mineral charcoal (sampled)		5
Coal, massive, containing lenses of mineral charcoal (sampled)	1	5
	4	2

21094. Bituminous coal from same mine and bed as No. 21092. Sample dry; cut at face of No. 8 cross entry, 4,500 feet S. 55° E. of main entry, February 17, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing lenses of sulphur (sampled)		4
Coal, slightly laminated (sampled)	1	10
Coal, containing bands of mineral charcoal (sampled)		5
	2	7

21095. Bituminous coal from same mine and bed as No. 21092. Sample dry; cut at face of No. 12 cross entry, 4,400 feet S. 55° E. of main entry, February 17, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and hard (sampled)		8
Coal, soft (sampled)		2
Coal, massive and hard (sampled)		8
Mineral charcoal (sampled)		½
Coal, laminated (sampled)		6
Coal, massive and hard (sampled)	1	8
	3	8½

21096. A composite of samples 21092 to 21095, inclusive.

21099. Bituminous coal from Slope mine of Conger Coal Co., 1½ miles northeast of Coalfield, on Harriman & Northeastern Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Sample wet; cut at mouth of No. 1 east entry, 250 feet northeast of slope mouth, February 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)		9½
Coal, bright and very hard (sampled)	1	1
Coal, bright and massive (sampled)	1	5½
Rash (sampled)		¼
Coal, massive (sampled)	1	2½
Coal (reported)		4
	4	10¾

21100. Bituminous coal from the Conger or Old Baker (drift) mine of Conger Coal Co., 1½ miles northeast of Coalfield, on Harriman & Northeastern Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample damp; cut at face of No. 2 right entry, 1,800 feet northeast of mouth, February 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive, bright, and hard (sampled)	3	10
Coal and sulphur lenses interbedded		5
	4	3

TENNESSEE—Continued.

21101. Bituminous coal from same mine and bed as No. 21100. Sample dry; cut at face of No. 6 right entry, 2,000 feet northeast of mouth, February 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale and lenses of coal interbedded		2
Coal, laminated (sampled)	2	4
Coal, very soft (sampled)		6
Sulphur kidney		½
Coal, hard and massive (sampled)		8½
Coal and sulphur lenses interbedded		2
	3	11

21102. Bituminous coal from same mine and bed as No. 21100. Sample dry; cut at face of No. 8 right entry, 2,000 feet northeast of mouth, February 23, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, coal, and sulphur lenses interbedded		2
Coal, soft and bright (sampled)		11
Coal, bright and hard (sampled)		7
Sulphur and coal interbedded		1
Coal, containing thin lenses of sulphur (sampled)	1	10
Coal and sulphur lenses interbedded		2
	3	9

21103. A composite of samples 21100 to 21102, inclusive.

21104. Bituminous coal from Bowing (drift) mine of Coalfield Coal Co., 1½ miles northeast of Coalfield, on Harriman & Northeastern Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is sandy shale. Sample dry; cut in No. 6 left entry, off No. 1 entry, 2,400 feet N. 30° W. of mouth, February 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	1	2
Coal, containing lenses of sulphur (sampled)		10
Clay, containing bands of coal		3
Clay		4
Coal, bright and soft (sampled)	1	8
	4	3

21105. Bituminous coal from same mine and bed as No. 21104. Sample damp and rib weathered; cut in main Fisher entry, 600 feet northeast of mouth, February 22, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing sulphur kidneys (sampled)		8½
Coal, rashy (sampled)		1
Coal, massive, containing some sulphur kidneys (sampled)	2	½
Clay, containing bands of coal		5
Coal (sampled)		11
Coal (reported)	1	0
	5	2

21106. Composite of samples 21104 and 21105.

21145. Bituminous coal from Coal Cut (drift) mine of J. A. Fagan, at Bluegem siding, on Harriman & Northeastern Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale or sandy shale and floor is clay. Sample dry and rib weathered; cut in main entry 250 feet east of mouth February 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, hard and bright (sampled)		9½
Rash and clay		½
Coal, bright and hard (sampled)		8½
Rash and clay		2
	1	8½

21146. Bituminous coal from Thornton (drift) mine of John Thornton, 1½ miles southeast of Coalfield, on Harriman & Northeastern Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample wet and weathered; cut at face of No. 1 left entry, 100 feet north and 50 feet west from mouth, Feb-

TENNESSEE—Continued.

ruary 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, blocky		9
Clay		2
Coal, badly crushed and mixed with clay		4
Coal, hard, bright, and massive (sampled)	2	3
	3	6

21147. Bituminous coal from Davis (wagon drift) mine of H. H. Davis, three-fourths of a mile west of Coalfield, on Harriman & Northeastern Railroad. Coal bed, Coal Creek (?); Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is sandy shale and floor is clay. Sample damp; cut in first right entry 200 feet east of main entry February 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and hard (sampled)	1	7
Clay with bands of rash interbedded	1	2
Coal (sampled)		11
Clay		11
Coal (sampled)		10
	5	5

21148. Bituminous coal (weathered) from Summers (wagon drift) mine, 8 miles east of Lancing, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Wartburg sandstone. Roof is sandstone and floor is clay. Sample wet; cut at face of main entry, 230 feet S. 30° E. of mouth, February 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and blocky (sampled)		10
Rash and clay interbedded		4
Coal, massive and blocky (sampled)	2	2
	3	4

21149. Bituminous coal (weathered) from Laymance (wagon drift) mine, 5 miles west of Stephens's switch, on Harriman & Northeastern Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age; Wartburg sandstone. Roof is sandy shale and floor is clay. Sample wet and weathered; cut from rib in main entry 200 feet south of mouth February 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, soft and laminated (sampled)		8
Coal, hard and massive (sampled)	2	6
	3	2

21150. Bituminous coal from Bottomlee (drift) mine of L. M. Bottomlee, 2 miles west-southwest of Bluegem siding, on Harriman & Northeastern Railroad. Coal bed, Blue Gem; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut in face of No. 1 right entry, 650 feet west of mouth, February 26, 1915, by F. R. Clark; represents 2 feet of hard, massive coal, entire thickness of bed.

21151. Bituminous coal (weathered) from Grassy Ridge (drift mine) of Chattanooga Gas Co., 1½ miles west of Christmas siding, on Harriman & Northeastern Railroad. Coal bed, Grassy Ridge; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is clay. Sample dry and weathered; cut from rib in main entry of new opening, 250 feet north of mouth, February 27, 1915, by F. R. Clark; represents 2 feet 1½ inches of hard, massive coal, total thickness of bed.

21152. Bituminous coal (weathered) from Harriman (slope) mine of Chattanooga Gas Co., half a mile west of Christmas siding, on Harriman & Northeastern Railroad. Coal bed, Hooper; Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample wet and rib weathered; cut from rib in main slope, 50 feet south of mouth, February 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal interbedded		3
Coal, hard and massive (sampled)	3	10
	4	1

TENNESSEE—Continued.

21153. Bituminous coal (weathered) from Smith (wagon drift) mine, a quarter of a mile south of Christmas siding, on Harriman & Northeastern Railroad. Coal bed, Hooper (?); Carboniferous age; formation not identified. Roof is sandy shale and floor is clay. Sample wet; cut from rib in main entry 100 feet south of mouth, February 27, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, very bright and hard (sampled)		4
Coal, very dull and very hard (sampled)		1½
Coal, bright, hard, and massive (sampled)		11½
Rash		2
	1	9

21412. Bituminous coal from Prudential (drift) mine of Prudential Coal Mining Co., 3½ miles northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and sandy shale and floor is clay. Sample damp; cut at face of No. 13 left entry, 850 feet north and 2,300 feet northwest from mouth, March 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		3
Coal, soft and badly crushed (sampled)		10
Coal, massive (sampled)	2	1
	3	2

21413. Bituminous coal from same mine and bed as No. 21412. Sample dry; cut at face of No. 12 left entry, 850 feet north and 2,000 feet northwest from mouth, March 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and sulphur lenses interbedded		1½
Coal, soft and badly crushed (sampled)	3	8½
	3	10

21414. Bituminous coal from same mine and bed as No. 21412. Sample dry; cut at face of No. 11 left entry, 850 feet north and 1,800 feet northwest from mouth, March 9, 1915, by F. R. Clark; represents 4 feet 4 inches of soft and badly crushed coal, total thickness of bed.

21415. Composite of samples 21412 to 21414, inclusive.

21416. Bituminous coal from Richards (drift) mine of Middle Creek Coal Co., 3 miles northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and sandy shale and floor is clay. Sample damp; cut at face of main face entry, March 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, containing thin bands of sulphur (sampled)	1	8
Coal, very dull and hard (sampled)		4
Coal, massive and badly crushed (sampled)	2	5
	4	5

21417. Bituminous coal from same mine and bed as No. 21416. Sample dry; cut at face of main entry, March 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash, coal, and sulphur lenses interbedded	1	2
Coal, containing lenses of sulphur (sampled)		10
Coal, badly crushed (sampled)	1	4
Sulphur kidney		3
Coal, crushed (sampled)	1	8½
Sulphur kidney		1
Coal, hard and massive (sampled)	3	6
	8	10½

21418. Composite of samples 21416 and 21417.

TENNESSEE—Continued.

21419. Bituminous coal from Williams (wagon drift) mine, operated by James Williams, 1½ miles north-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample cut in main entry 100 feet west of mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and rash interbedded (sampled)		5
Coal, bright, hard, and blocky (sampled)	2	6
Rash		10
	3	9

21420. Bituminous coal from Levan (wagon drift) mine, operated by W. H. Levan, 1½ miles west-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Old Eagle; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut at face of Butt entry, 250 feet north of mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and rash interbedded		5
Coal, very hard, massive, and blocky (sampled)	1	10
Coal and rash interbedded		3
	2	6

21421. Bituminous coal from Old Mount Carbon (drift) mine, operated by John Roddy, 2½ miles north-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry but shows no appreciable weathering after about 14 years' exposure to the mine air; cut in main entry, 75 feet east of mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal interbedded		2
Coal, bright, massive, and splint-like (sampled)	2	8
	2	10

22422. Bituminous coal from Signal Mountain (drift) mine of Signal Mountain Coal Co., 2½ miles north-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample dry; cut at face of main entry, 250 feet north of mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal with thin bands of sulphur interbedded (sampled)		7
Coal, massive, bright, and hard (sampled)	2	0
	2	7

21423. Bituminous coal from Poplar Creek (drift) mine of Butler & Denton, 4 miles north-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry and rib weathered; cut from rib in main entry 400 feet north of mouth March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bedded, containing some rash (sampled)		7
Clay		2
Coal, soft and bedded (sampled)		7½
Sulphur kidney		½
Coal, massive and hard (sampled)	2	8
	4	1

21424. Bituminous coal from Big Mountain (drift) mine of Big Mountain Coal Co., 3¼ miles north-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Penn-

TENNESSEE—Continued.

sylvanian) age; Briceville shale. Sample dry and possibly slightly weathered; cut from rib in main entry, 300 feet north of mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal interbedded		1
Coal, massive and blocky (sampled)		6
Clay		3
Coal, massive and blocky (sampled)	2	7
Coal (under water)		4
	3	9

21425. Bituminous coal from Reed (drift) mine of Oliver Springs Coal & Clay Co., 1 mile west-northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, not identified; Carboniferous (Pennsylvanian) age; Lee (?) formation. Roof is shale and floor is fire-clay. Sample dry; cut at face of No. 2 right entry, 800 feet north and 500 feet east from mouth, March 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing thin bands of rash and sulphur (sampled)		4
Coal, massive and hard (sampled)	1	6
	1	10

21426. Bituminous coal from Jackson (drift) mine of Jackson Coal Co., 1¾ miles northwest of Oliver Springs, on Southern Railway and Louisville & Nashville Railroad. Coal bed, Coal Creek; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and sandy shale and floor is clay. Sample dry and possibly slightly weathered; cut from rib in main entry 400 feet northwest of mouth March 9, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing some rash		2½
Coal, massive, very hard, and flinty (sampled)	2	0
Coal, soft and badly crushed (sampled)		10
	3	½

21428. Bituminous coal from Catoosa (drift) mine of Tennessee Timber, Coal & Iron Co., 3 miles west-southwest of Nemo, a station on the Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Walden Ridge; Carboniferous (Pennsylvanian) age; Lee (?) formation. Roof is sandy shale and floor is clay and sandy shale. Sample dry and possibly slightly weathered; cut at face of room 2 off No. 1 right entry, 75 feet north of mouth, March 8, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in
Coal		1
Rash and shale intermixed		5
Coal, soft and crushed (sampled)	2	2
	2	8

OVERTON COUNTY.

20978. Bituminous coal from Overton (drift) mine of Overton Coal & Coke Co., 2½ miles northwest of Highland Junction, on Crawford branch of Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Lee formation. Roof is sandy shale and floor is shale. Sample damp; cut at face of main straight entry, 460 feet southwest of mouth, February 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal		3
Sulphur kidney		1½
Coal (sampled)		7½
Coal, impure, containing sulphur kidneys		1
Coal, massive (sampled)	3	6½
	4	7½

20979. Bituminous coal from same mine and bed as No. 20978. Sample damp; cut at face of main entry, 1,200 feet N. 20° W. of mouth, February 10, 1915, by

TENNESSEE—Continued.

F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, interbedded with bands of shale		3
Coal, laminated, containing thin lenses of sulphur (sampled)	1	0
Coal, impure (sampled)		1
Coal, massive (sampled)	3	6
	4	10

20980. Bituminous coal from same mine and bed as No. 20978. Sample damp and rib weathered; cut in No. 1 left entry, 500 feet from mouth, February 10, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, containing thin bands of shale		2
Coal (sampled)	1	1
Sulphur kidney		2
Coal, massive (sampled)	3	4
	4	9

20981. Composite of samples 20978 to 20980, inclusive.

20991. Bituminous coal from Obey River (drift) mine of Obey River Coal Co., half a mile east of Obey City station, on Crawford branch of Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Lee (?) formation. Roof is sandy shale and floor is shale. Sample dry and rib weathered; cut at face of cross entry, off No. 1 left entry, 500 feet northeast of mouth, February 11, 1915, by F. R. Clark. The mine was not in operation at the time the sample was taken. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	4½
Rash		5
	2	9½

20992. Bituminous coal from Peacock (drift) mine of Peacock Coal Co., one-eighth mile west of Obey City station, on Crawford branch of Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Lee (?) formation. Roof is sandstone and floor is shale. Sample dry and fresh; cut at face of cross entry off No. 1 right entry, 1,000 feet southwest of mouth, February 11, 1915, by F. R. Clark; represents 2 feet 6 inches of massive coal, entire thickness of bed.

PUTNAM COUNTY.

20990. Bituminous coal from Monterey (drift) mine, operated by R. E. Hodge, 2 miles north of Monterey, on Tennessee Central Railroad. Coal bed, Bon Air No. 2; Carboniferous (Pennsylvanian) age; Bonair sandstone. Sample damp; cut at face of main entry, 200 feet south of drift mouth, February 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated (sampled)		9½
Coal, locally containing sulphur kidneys (sampled)		1
Coal, laminated (sampled)	1	4
Sulphur kidney		1½
Coal (sampled)	1	6½
Rash		5
	4	3½

RHEA COUNTY.

22158. Bituminous coal from Montague No. 6 (slope) mine of Durham Coal & Iron Co., 2 miles north of Graysville, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Nelson (lower bench); Carboniferous (Pennsylvanian) age; Lookout sandstone. Roof and floor sandstone. Sample dry; cut in face of room 1 off main entry, 400 feet west of mouth, May 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale		2
Coal, steel-gray, very hard, and brittle (sampled)	2	7
	2	9

22159. Bituminous coal from Montague No. 1 (drift) mine of Durham Coal & Iron Co., 2½ miles north of Graysville, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Nelson (top bench); Carboniferous (Pennsylvanian) age; Look-

TENNESSEE—Continued.

out sandstone. Roof is sandy shale and floor is sandstone. Sample dry; cut from air-course pillar off No. 2 haulage off No. 1 main entry, May 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Clay		1
Rash		3
Coal, badly crushed and contorted (sampled)	2	4
	2	10

22165. Bituminous coal from same mine and bed as No. 22159. Sample dry; cut from chain pillar off main entry May 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay		4
Rash		2
Coal, impure and badly crushed (sampled)		7
Shale		1
Coal, steel-gray and badly crushed (sampled)	2	7
	3	9

22180. Bituminous coal from Montague No. 3 (drift) mine of Durham Coal & Iron Co., 2½ miles north of Graysville, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are sandy shale. Sample dry; cut at face of No. 8 right entry, 3,200 feet N. 20° E. and 500 feet S. 70° E. from mouth, April 30, 1915, by F. R. Clark. Sample represents 1 foot 10 inches of laminated and lustrous coal, entire thickness of bed.

22181. Bituminous coal from Montague No. 5–A (drift) mine of Durham Coal & Iron Co., 2⅝ miles north of Graysville, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof and floor are sandstone. Sample dry; cut at face of No. 2 right entry, 600 feet east of mouth, April 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal and rash interbedded		3
Coal, badly crushed (sampled)	3	4
Rash	1	0
	4	7

22182. Bituminous coal from same mine and bed as No. 22181. Sample dry; cut at face of No. 2 left entry, 1,200 feet north of mouth, April 30, 1915, by F. R. Clark; represents 2 feet 11 inches of lustrous, badly crushed coal, total thickness of bed.

22183. Bituminous coal from Montague No. 5–B (drift) mine of Durham Coal & Iron Co., 2¾ miles north of Graysville. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is sandy shale and floor is sandstone. Sample dry; cut from pillar off No. 1 right entry, 600 feet south of mouth, April 30, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Clay		2
Coal, laminated and crushed (sampled)	2	11½
Rash		2
	3	3½

22184. Composite of samples 22180 to 22183, inclusive.

ROANE COUNTY.

21015.[1] Bituminous coal from Rockwood (slope) mine of Knox Mining Co., three-quarters of a mile west of Rockwood station, on Tennessee Central Railroad. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is shale and floor is clay. Sample dry; cut in Bill Mahorn's place off No. 2 entry, 10,500 feet northwest of mouth, February 15, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

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[1] Owing to the crushed condition of the coal in the Rockwood mine the ash varies greatly, ranging from about 9 per cent where there is little admixture of foreign material to over 20 per cent where the shale is intimately mixed with the coal.

TENNESSEE—Continued.

	Ft.	in.
Coal, crushed (sampled)		6
Shale		¼
Coal, badly crushed (sampled)	1	6¾
Shale and coal intermixed		4
Coal, badly crushed (sampled)	2	6
	4	11

21016. Bituminous coal from same mine and bed as No. 21015. Sample dry; cut at face of Lee McNeil's place, 10,500 feet N. 20° W. of mouth, February 15, 1915, by F. R. Clark. Sample represents 3 feet of soft and badly crushed coal, total thickness of bed.

21017. Bituminous coal from same mine and bed as No. 21015. Sample dry; cut at face of John Long's place off No. 9 entry, 11,500 feet N. 15° E. of mouth, February 15, 1915, by F. R. Clark; represents 4 feet 10 inches of soft and badly crushed coal, total thickness of bed.

21018. Bituminous coal from same mine and bed as No. 21015. Sample dry; cut at face of W. T. Acuff's place off No. 10 entry, 6,500 feet north of mouth, February 15, 1915, by F. R. Clark; represents 4 feet ½ inch of soft and badly crushed coal, total thickness of bed.

21023.[1] Bituminous coal from McLean (slope) mine of Knox Mining Co., three-quarters of a mile south of McLean siding, on Tennessee Central Railroad. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is shale and floor is clay. Sample cut at face of Sam Day's place, 3,000 feet N. 70° W. of mouth, February 13, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and carbonaceous shale		6
Coal, rashy and badly crushed (sampled)	4	3
	4	9

21024. Bituminous coal from same mine and bed as No. 21023. Sample dry; cut at face of Hartberger's place, 700 feet northwest of mouth, February 13, 1915, by F. R. Clark; represents 4 feet of soft, crushed coal, total thickness of bed.

21062. Bituminous coal from Walden Ridge (slope) mine of E. F. Blizzard, 2 miles northeast of Harriman, on Southern Railway. Coal bed, Walden Ridge; Carboniferous (Pennsylvanian) age; Lookout sandstone. Roof is sandy shale and floor is clay. Sample damp; cut at face of room 1 off No. 1 right entry, 300 feet north of mouth, February 16, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		2
Coal, massive and hard (sampled)	2	6
	2	8

SCOTT COUNTY.

21154. Bituminous coal from Phillips (drift) mine of Virginia Mining Co., 3 miles west of Bear Creek Junction, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, No. 4; Carboniferous age; formation not identified. Roof is shale and floor is clay. Sample dry; cut at face of room 17 off No. 2 right entry, 600 feet west and 1,100 feet north from mouth, March 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bedded and hard (sampled)	1	0
Bone	1	1
Coal, massive and hard (sampled)	1	5
	3	6

21155. Bituminous coal from same mine and bed as No. 21154. Sample dry; cut at mouth of No. 6 right entry off main entry, 1,800 feet west of mouth, March 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated and hard (sampled)	1	0
Bone		11
Coal, massive and hard (sampled)	1	7
	3	6

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[1] Owing to the crushed condition of the coal in the McLean mine the ash varies greatly, ranging from about 9 per cent where there is little admixture of foreign material to over 20 per cent where the shale is intimately mixed with the coal.

TENNESSEE—Continued.

21156. Composite of samples 21154 and 21155.

21219. Bituminous coal from Wilson (drift) mine of Virginia Mining Co., 3 miles west of Bear Creek Junction, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, No. 4; Carboniferous age; formation not identified. Roof is shale and floor is clay. Sample dry; cut at face of room 7 off No. 4 south entry, 200 feet west and 600 feet south from mouth, March 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated and hard (sampled)	1	2
Bone and coal interbedded		9
Coal, massive and hard (sampled)	1	5
Rash, coal, and sulphur lenses		2
	3	6

21220. Bituminous coal from same mine and bed as No. 21219. Sample dry; cut at face of room 10 off No. 1 north entry, 700 feet north of mouth, March 1, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated and hard (sampled)	1	7
Shale, containing thin lenses of coal	1	3
Bone		5
Coal, massive and hard (sampled)	1	7
	4	10

21221. Composite of samples 21219 and 21220.

21218. Sample taken from a railroad car of slack coal from the Phillips and Wilson mines, which had been run through the coal washer for the purpose of removing the impurities.

21222. Bituminous coal from Cross (wagon drift) mine of W. A. Cross, at Cross's crossing, on Tennessee Railway. Coal bed, Paint Rock; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample damp; cut at face of main entry, 100 feet northwest of mouth, March 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and soft (sampled)		5
Coal, very dull and very hard (sampled)		3
Coal, massive, bright, and hard (sampled)	1	0
	1	8

21223. Bituminous coal from Opossum Jaw (drift) mine of George Chambers, half a mile south of Jakes Tank station, on Tennessee Railway. Coal bed, Paint Rock (?); Carboniferous (Pennsylvanian) age; Briceville shale. Roof is shale and floor is clay. Sample damp and weathered; cut at face of room No. 2 (right) off main entry, 100 feet south and 25 feet west from mouth, March 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, rashy (sampled)		2
Coal, massive and hard (sampled)	1	6
	1	8

21224. Bituminous coal from Sexton (drift) mine of Sexton Bros., 1,000 feet southeast of Stanley Junction station, on Tennessee Railway. Coal bed, Paint Rock; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample cut at face of main entry, 200 feet northeast of mouth, March 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Bone and shale interbedded		9
Coal, bright and soft (sampled)		4
Coal, very dull and very hard (sampled)		2
Coal, massive, bright, and hard (sampled)	1	10
	3	1

21225. Bituminous coal from Pumpkin Hollow (drift) mine of Archie McDonald, one-fourth of a mile northwest of Jakes Tank station, on Tennessee Railway. Coal bed, Paint Rock; Carboniferous (Pennsylvanian) age; Briceville shale. Sample dry and possibly slightly weathered; cut from rib in main entry, 250 feet

TENNESSEE—Continued.

west of mouth, March 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, containing thin lenses of coal		4
Coal, bright and soft (sampled)		4
Coal, very dull and very hard (sampled)		2
Coal, massive, bright, and hard (sampled)	1	9
	2	7

21226. Bituminous coal from Jakes Branch (drift) mine of Archie McDonald, one-fourth of a mile west of Jakes Tank station, on Tennessee Railway. Coal bed, Paint Rock; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry and rib weathered; cut from rib on No. 2 right entry, 300 feet from mouth, March 3, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and soft (sampled)		5
Coal, very dull and very hard (sampled)		3
Coal, bright, massive, and hard (sampled)	1	2
	1	10

21227. Bituminous coal from Keaton (drift) mine of Keaton Bros., 1,000 feet northwest of Stanley Junction station, on Tennessee Railway. Coal bed, Paint Rock; Carboniferous (Pennsylvanian) age; Briceville shale. Sample cut in main entry, 200 feet south-southwest of mouth, March 4, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, containing thin lenses of coal	1	2
Coal, bright and soft (sampled)		6
Coal, very dull and very hard (sampled)		1
Coal, massive, bright, and hard (sampled)	1	9
	3	6

21228. Bituminous coal from Clay No. 1 (drift) mine of Southern Clay Manufacturing Co., 1 mile south of Robbins, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Blue Gem (?); Carboniferous (Pennsylvanian) age; Wartburg sandstone (?). Roof is shale and floor is fire clay. Sample dry; cut at face of main entry, 1,000 feet south of mouth, March 5, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash		5
Coal, bright and massive (sampled)	1	5
Clay		1
Coal, bright (sampled)		4
	2	3

21229. Bituminous coal from Hughett (wagon drift) mine of Jasper Hughett, half a mile south of Robbins, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Blue Gem (?); Carboniferous (Pennsylvanian) age; Wartburg (?) sandstone. Sample dry; cut at face of main entry, 300 feet east of mouth, March 5, 1915, by F. R. Clark; represents 1 foot 1 inch of hard, massive coal, total thickness of bed.

21272. Bituminous coal from Arch Mountain (drift) mine of Baker Coal & Coke Co., 1,500 feet west of Newland station, on Tennessee Railway. Coal bed, Jellico; Carboniferous (Pennsylvanian) age; Briceville shale. Roof is sandy shale and floor is clay. Sample dry; cut at face of No. 2 left entry, 300 feet southwest, 270 feet northwest, and 140 feet southwest from mouth, March 2, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive	1	4
Shale, with thin lenses of coal interbedded		7
Coal, massive (sampled)	1	4
	3	3

21314. Bituminous coal (weathered) from Hughett (drift) prospect of James Chambers, 8 miles southeast of Robbins, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, Mud Slip;

TENNESSEE—Continued.

Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample wet; cut from face of entry, 25 feet west of mouth, March 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, soft and laminated (sampled)		7
Coal, massive (sampled)	2	9
	3	4

21315. Bituminous coal (weathered) from Newman (drift) prospect of Newman & Walker, 6 miles south-southeast of Robbins, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample damp; cut at face of main entry, 200 feet south of mouth, March 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive and blocky (sampled)	1	8
Shale	1	5
Coal, bedded, containing some rash (sampled)	1	0
Coal, massive and blocky (sampled)	2	2
	6	3

21316. Bituminous coal (weathered) from drift prospect of Will Long, 6 miles southeast of Robbins, on Cincinnati, New Orleans & Texas Pacific Railway. Coal bed, not identified; Carboniferous (Pennsylvanian) age; Briceville shale (?). Roof is shale and floor is clay. Sample cut at face of entry, 20 feet north of mouth, March 6, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Rash and coal interbedded		4
Coal, massive (sampled)	2	0
	2	4

SEQUATCHIE COUNTY.

22239. Bituminous coal from Douglas No. 2 (drift) mine of Chattanooga Iron & Coal Co., 2 miles west of Dunlap, on Pikeville branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee; Carboniferous (Pennsylvanian) age; "Walden sandstone." Roof is shale and sandy shale and floor is shale. Sample dry; cut at face of No. 9 north entry off No. 22 west entry, 4,500 feet N. 9° W., 2,350 feet S. 19° W., and 1,600 feet N. 9° W. from mouth, May 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, laminated, containing some rash (sampled)	1	1
Coal, lustrous and contorted (sampled)	4	3
Shale and bone		1
Coal		2
	5	7

22240. Bituminous coal from same mine and bed as No. 22239. Sample cut at face of No. 6 north entry off No. 22 west entry, 4,500 feet N. 9° W., 1,675 feet S. 19° W., and 1,800 feet N. 9° W. from mouth, May 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, bright and laminated (sampled)		7
Coal, dull, steel-gray, and hard (sampled)	1	0
Coal, lustrous and soft (sampled)		6
Rash and coal interbedded		4
Coal, soft and laminated (sampled)		10
	3	3

22241. Bituminous coal from same mine and bed as No. 22239. Sample dry; cut in room 32 off No. 10 north off No. 22 west entry, 4,500 feet N. 9° W., 2,400 feet S. 19° W., and 1,300 feet N. 9° W. from mouth, May 12, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Shale, carbonaceous		2
Coal, rashy, containing thin bands of mineral charcoal (sampled)		4
Coal, very bright, containing bands of dull coal (sampled)	3	10
	4	4

22242. Composite of samples 22239 to 22241, inclusive.

TENNESSEE—Continued.

WHITE COUNTY.

22365. Bituminous coal from Bon Air (shaft) mine of Bon Air Coal & Iron Co., 1¼ miles south of Bon Air, on Sparta branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Bon Air (lower bench); Carboniferous age; formation not identified. Depth of shaft to base of coal bed, 212 feet. Roof and floor are shale. Sample dry; cut at face of main airway, 2,020 feet S. 41° E. of shaft landing, May 24, 1915, by F. R. Clark; represents 2 feet 7 inches of bedded coal, entire thickness of bed.

22366. Bituminous coal from same mine and bed as No. 22365. Sample dry; cut at face of No. 2 east entry, 200 feet S. 41° E. and 900 feet N. 50° E. from shaft landing, May 25, 1915, by F. R. Clark; represents 2 feet 11½ inches of hard, massive coal, total thickness of bed.

22367. Bituminous coal from same mine and bed as No. 22365. Sample dry; cut at face of main west entry, 1,030 feet N. 41° W. and 400 feet N. 13° W. from shaft landing, May 25, 1915, by F. R. Clark; represents 3 feet of hard, massive coal containing thin bands of sulphur, total thickness of bed.

22368. A composite of samples 22365 to 22367, inclusive.

22369. Bituminous coal (rib weathered) from same mine and bed as No. 22365. Sample dry; cut from rib on No. 3 east entry, 200 feet from main face entry, May 24, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous and hard (sampled)		2
Bone		¼
Coal, cannel (sampled)		7
Coal, massive, bright, and very hard (sampled)	2	6
	3	3¼

22393. Bituminous coal from Ravenscroft (shaft) mine of Bon Air Coal & Iron Co., half a mile northeast of Ravenscroft, on Sparta branch of Nashville, Chattanooga & St. Louis Railway. Coal bed, Bon Air (?); Carboniferous age; formation not identified. Roof is sandstone and floor is shale. Depth of shaft to base of coal bed, 178 feet. Sample dry; cut at face of cross entry off Will Marr entry, 1,500 feet northeast of shaft landing, May 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, massive, containing thin bands of sulphur (sampled)	4	2
Clay		2
Rash		4
	4	8

22394. Bituminous coal from same mine and bed as No. 22393. Sample dry; cut at face of Kelley entry, 2,000 feet north of shaft landing, May 25, 1915, by F. R. Clark; represents 3 feet 8 inches of hard, massive coal, entire thickness of bed.

22395. Bituminous coal from same mine and bed as No. 22393. Sample dry; cut at face of Campbell entry, 2,700 feet east of shaft landing, May 25, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	in.
Coal, lustrous (sampled)		3
Coal, containing thin lenses of sulphur (sampled)	1	5
Sulphur kidney		½
Coal, massive and very hard (sampled)	1	11
Sulphur kidney		½
Coal, massive and very hard (sampled)		10
	4	6

22396. Bituminous coal from same mine and bed as No. 22393. Sample dry; cut in room off new west works, 1,700 feet west of shaft landing, May 25, 1915, by F. R. Clark; represents 4 feet 9 inches of massive coal, containing thin bands of sulphur and mineral charcoal, entire thickness of bed.

22397. Composite of samples 22393 to 22396, inclusive.

22388. Bituminous coal from Clifty No. 1 (drift) mine of Clifty Consolidated Coal Co., a quarter of a mile east of Clifty, at terminus of Sparta branch of

TENNESSEE—Continued.

Nashville, Chattanooga & St. Louis Railway. Coal bed, Sewanee (?); Carboniferous (Pennsylvanian) age; "Walden sandstone" (?). Roof is sandstone and floor is shale. Sample wet; cut at face of No. 1 west entry, 3,450 feet N. 5° W., 3,225 feet N. 86° W., and 3,150 feet west from mouth, May 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	In.
Coal, laminated (sampled)		10
Coal, massive and hard (sampled)	1	3
Coal, soft (sampled)	1	5
	3	6

22389. Bituminous coal from same mine and bed as 22388. Sample dry; cut at face of No. 8 west entry, 3,450 feet N. 5° W., 3,225 feet N. 86° W., 1,750 feet north, and 1,950 feet west from mouth, May 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	In.
Coal, bright and hard (sampled)		9
Sulphur		½
Coal, bright and very hard (sampled)	1	6
Sulphur		½
Coal, massive and hard (sampled)	1	0
	3	4

22390. Bituminous coal from same mine and bed as No. 22388. Sample wet; cut at face of No. 3 main air course, 3,450 feet N. 5° W., 3,225 feet N. 86° W., 2,150 feet west, and 1,050 feet north from mouth, May 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	In.
Coal, laminated (sampled)		7
Coal, massive and hard (sampled)	2	6
	3	1

22391. Bituminous coal from same mine and bed as No. 22388. Sample wet; cut at face of No. 3 west entry, 3,450 feet N. 5° W., 3,225 feet N. 86° W., 2,150 feet west, 425 feet north, and 280 feet west from mouth, May 26, 1915, by F. R. Clark. Section of bed at point sampled is as follows:

	Ft.	In.
Coal, laminated and soft (sampled)		8½
Coal, massive and hard (sampled)	1	0
Sulphur		1½
Coal, soft (sampled)	2	2
	4	0

22392. Composite of samples 22388 to 22391, inclusive.

UTAH.

CARBON COUNTY.

19680. Bituminous coal from Kenilworth (slope) mine of Independent Coal & Coke Co., in NW. ¼ sec. 16, T. 13 S., R. 10 E., three-quarters of a mile north of Kenilworth, at terminus of Kenilworth & Helper Railroad. Coal bed, Aberdeen; Upper Cretaceous age; Mesaverde formation. Roof and floor are coal. Sample cut from face of No. 10 right entry, 2,260 feet N. 30° W., 1,700 feet west, and 790 feet east from mine mouth, July 16, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	In.
Coal	Thickness not known.	
Coal (sampled)	6	10
Coal	Thickness not known.	

19711. Bituminous coal from same mine as No. 19680. Coal bed, Aberdeen; Upper Cretaceous age; Mesaverde formation. Roof and floor are coal. Sample dry; cut in room 7 off No. 9 left entry, 2,200 feet N. 30° W., 1,200 feet north, 530 feet west, and 100 feet S. 37° W. from mine mouth, July 24, 1914, by F. R. Clark; represents 16 feet 2 inches of coal, only partial thickness of bed.

19681. Bituminous coal from same mine as No. 19680. Coal bed, Kenilworth; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is coal. Sample dry; cut from face of main slope, 1,950 feet N. 33° W., 140 feet N. 19° E., 510 feet north, 165 feet west, and 165 feet north from mine mouth, July 16, 1914, by

UTAH—Continued.

F. R. Clark. Section at point sampled is as follows:

	Feet.
Coal	2
Shale, sandy	3
Coal	2
Coal (sampled)	8
Coal	Thickness not known.

19712. Bituminous coal from same mine as No. 19680. Coal bed, Kenilworth; Upper Cretaceous age; Mesaverde formation. Roof and floor are coal. Sample dry; cut at face of No. 1 left back entry, 1,930 feet N. 33° W., 150 feet N. 19° E., 455 feet north, 165 feet west, and 300 feet S. 70° W. from mine mouth, July 24, 1914, by F. R. Clark; represents 7 feet of coal, partial thickness of bed. Coal left as floor about 1 foot; thickness of roof coal not determined.

19682. Bituminous coal from same mine as No. 19680. Coal bed, Royal Blue; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is shale. Sample dry; cut from face of No. 1 right entry up new tunnel, 1,930 feet N. 33° W., 140 feet N. 19° W., 290 feet north, and 100 feet east from mine mouth, July 16, 1914, by F. R. Clark; represents 5 feet 7 inches of coal, entire thickness of bed.

19710. Bituminous coal from same mine as No. 19680. Coal bed, Royal Blue; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample wet; cut in room 3 off No. 2 west entry, 350 feet N. 7° W., 250 feet N. 81° W., and 250 feet S. 57° W. from mine mouth, July 24, 1914, by F. R. Clark; represents entire bed. Section at point sampled is as follows:

	Ft.	in.
Coal, soft		8
Coal, dull, hard		2
Coal, bright, hard	1	8
Bone		½
Coal, bright, hard	1	8
Bone		1
Coal, very hard	2	3
	6	6½

19702. Bituminous coal from Aberdeen (wagon drift) mine, in SW. ¼ sec. 10, T. 13 S., R. 10 E., 1½ miles northeast of Kenilworth, at terminus of Kenilworth & Helper Railroad. Coal bed, Aberdeen; Upper Cretaceous age; Mesaverde formation. Roof is sandstone and floor is coal. Sample dry; cut 460 feet west of mine mouth July 23, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	10	10
Coal	3	4
	14	2

19706. Bituminous coal from Milburn (wagon drift) mine, in SW. ¼ sec. 11, T. 13 S., R. 10 E., 2¼ miles northeast of Kenilworth, at terminus of Kenilworth & Helper Railroad. Coal bed, Kenilworth; Upper Cretaceous age; Mesaverde formation. Sample cut 100 feet N. 55° W. and 90 feet north from mine mouth July 23, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Shale, brown		9
Coal (sampled)	6	4
Coal	4	10
	11	11

19843. Bituminous coal from Castlegate No. 2 (drift) mine of Utah Fuel Co., in NW. ¼ sec. 6, T. 13 S., R. 10 E., three-fourths of a mile northeast of Castlegate, on Denver & Rio Grande Railroad. Coal bed, "D"; Upper Cretaceous age; Mesaverde formation. Roof and floor are coal. Sample cut in No. 1 left main entry off No. 1 rise, 3,200 feet south of mine mouth, September 23, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal	Thickness unknown.	
Bone		½
Coal (sampled)	3	3
Bone		1
Coal (sampled)		3
Bone		½
Coal (sampled)	3	4
Coal, cut by machine		6
Coal	Thickness unknown.	
	7	6+

19845. Bituminous coal from same mine as No. 19843. Coal bed, "B"; Upper Cretaceous age; Mesaverde formation.

UTAH—Continued.

Roof and floor are sandstone. Sample cut at face of No. 4 right entry off No. 1 rise, 1,700 feet S. 30° E. of mine mouth, September 23, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal		6
Bone		3
Coal (sampled)		6
Bone		3
Coal (sampled)		7
Bone		2
Coal (sampled)	3	5
Bone		5
Coal (sampled)		8
Coal	Thickness unknown.	
	6	9+

19844. Bituminous coal from Castlegate No. 1 (slope) mine of Utah Fuel Co., in NW. ¼ sec. 1, T. 13 S., R. 9 E., at Castlegate, on Denver & Rio Grande Railroad. Coal bed "D"; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample cut in mine in No. 1 right entry off No. 1 dip, 5,400 feet S. 66° W. and 1,400 feet N. 45° W. from mine mouth, September 22, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	4	10
Coal		2
	5	0

19846. Bituminous coal from same mine as No. 19844. Coal bed "C"; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample cut in room 18 off No. 4 right entry off No. 1 rise, 5,400 feet S. 66° W. and 1,900 feet S. 45° W. from mine mouth, September 22, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Bone		3
Coal (sampled)	5	7
	5	10

19847. Bituminous coal from same mine as No. 19844. Coal bed, "A"; Upper Cretaceous age; Mesaverde formation. Roof is coal and floor is sandstone. Sample dry; cut at entry stump on No. 12 level off No. 10 rise 4,000 feet S. 66° W.; 4,650 feet S. 4° W., and 200 feet S. 80° E. from mine mouth, September 22, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal		8±
Coal (sampled)	7	4½
Bone		3
	8	3½±

19880. Bituminous coal from No. 1 (slope) mine of Cameron Coal Co., in sec. 35, T. 12 S., R. 9 E., 1½ miles northwest of Castlegate, on Denver & Rio Grande Railroad. Coal Bed No. 1; Upper Cretaceous age; Mesaverde formation. Sample cut in second left main entry 800 feet south and 50 feet west from slope mouth, September 24, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (mine roof)		8
Coal (sampled)	5	6½
Coal (mine floor)		6
	6	8½

19879. Bituminous coal from No. 2 (slope) mine of Cameron Coal Co., in NE. ¼ sec. 35, T. 12 S., R. 9 E., 1½ miles northwest of Castlegate, on Denver & Rio Grande Railroad. Coal bed No. 2; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample cut at face of main rise entry, 900 feet S. 85° W. of mine mouth, September 24, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal, not mined	2±	
Bone, mine roof		4
Coal (sampled)	5	0
Coal, cut by machine		6½
Coal, mine floor		9
	8	7½±

19881. Bituminous coal from Panther (slope) mine of Panther Coal Co., in sec. 1, T. 13 S., R. 9 E., 1¼ miles north of Carbon post office, on Denver & Rio Grande Railroad. Coal bed, Castlegate; Upper Cretaceous age; Mesaverde formation. Roof

UTAH—Continued.

and floor are shale. Sample cut at face of No. 2 east entry off main slope, 1,000 feet N. 45° E. and 500 feet east from mouth, September 25, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal		4
Bone		5
Coal (sampled)	6	2½
	6	11½

19837. Bituminous coal from drift prospect in Hardscrabble Canyon, in SW. ¼ NE. ¼ sec. 10, T. 13 S., R. 9 E., 3 miles northwest of Helper, on Denver & Rio Grande Railroad. Coal bed, Spring Canyon No. 1; Upper Cretaceous age; Mesaverde formation. Roof is sandy shale and floor is sandstone. Sample dry and possibly slightly weathered; cut at face of main entry, 350 feet S. 35° W. of opening, September 19, 1914, by F. R. Clark; represents 4 feet ½ inch of coal, entire thickness of bed.

19838. Bituminous coal from drift prospect near same prospect and from same bed as No. 19837. Sample dry and perhaps slightly weathered; cut at face of main entry, 400 feet S. 70° W. of mine mouth, September 19, 1914, by F. R. Clark; represents 4 feet of coal, entire thickness of bed.

19986. Bituminous coal from No. 1 (slope) mine of Spring Canyon Coal Co., in sec. 9, T. 13 S., R. 9 E., at Storrs, on Spring Canyon Railroad. Coal bed, Spring Canyon No. 1: Upper Cretaceous age; Mesaverde formation. Roof is shale and floor is sandstone. Sample wet; cut at face of No. 4 right entry off main entry, 1,720 feet N. 32° W. of mine mouth, October 16, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	6	4
Bone		2
Coal (sampled)	2	2
Coal		4
	9	0

19987. Bituminous coal from No. 2 (drift) mine of Spring Canyon Coal Co., in sec. 9, T. 13 S., R. 9 E., at Storrs, on Spring Canyon Railroad. Coal bed, Spring Canyon No. 2; Upper Cretaceous age; Mesaverde formation. Roof and floor are shale. Sample cut at face of main entry, 810 feet east of mine mouth, October 17, 1914, by F. R. Clark; represents 4 feet 2½ inches of coal, entire thickness of bed.

19990. Bituminous coal from No. 3 (drift) mine of Spring Canyon Coal Co., in sec. 9, T. 13 S., R. 9 E., at Storrs, on Spring Canyon Railroad. Coal bed, Spring Canyon No. 3; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample dry; cut at face of main entry October 17, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	3	10
Bone		½
Coal (sampled)	3	10
Coal		8
	8	4½

19988. Bituminous coal from Standard (drift) mine of Standard Coal Co., in sec. 8, T. 13 S., R. 9 E., at Standardville, terminus of Spring Canyon Railroad. Coal bed, Castlegate; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample dry; taken in crosscut 200 feet S. 50° E. of face of fan way or 1,450 feet N. 50° W. of mine mouth October 17, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (on roof)	1	0
Coal (sampled)	8	2
Coal, cannel (sampled)		1
Bone		1½
Coal (lower bench)	5	8
	15	½

19989. Bituminous coal from same mine as No. 19988. Coal bed, Castlegate; Upper Cretaceous age; Mesaverde formation. Roof and floor are sandstone. Sample dry; cut 150 feet from face of fan way or 1,550 feet N. 50° W. of mine mouth October 17, 1914, by F. R. Clark. Section at point sampled is as follows:

UTAH—Continued.

	Ft.	in.
Coal	8±	
Coal, cannel		1
Bone		8
Coal (sampled)	1	8
Bone		1
Coal (sampled)	3	4
Coal		10
	14	8±

MORGAN COUNTY.

19799. Subbituminous coal from Robinson (drift) mine of Heber Robinson, in sec. 28, T. 5 N., R. 5 E., in Toone Canyon, 12 miles northeast of Devils Slide station, on Union Pacific Railroad. Coal bed, no name; Tertiary age (?); formation not determined. Roof is shale and floor is coal. Sample probably slightly weathered; cut 300 feet northeast of opening September 5, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	8
Bone		2
Coal, dull, earthy (sampled)		5
Coal, bright (sampled)	1	2
Coal, dull (sampled)		2
Coal (sampled)	1	7
Coal	1	0
	6	2

19800. Subbituminous coal from abandoned slope mine of W. Lucas and H. C. Smith, in sec. 17, T. 5 N., R. 5 E., 12½ miles northeast of Devils Slide station, on Union Pacific Railroad. Coal bed, no name; Tertiary age (?); formation not determined. Roof is shale and sandstone and floor is shale. Sample slightly weathered; cut from rib 200 feet west of opening September 5, 1914, by F. R. Clark. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	5
Bone		9
	2	2

SUMMIT COUNTY.

20894. Bituminous coal from prospect in NE. ¼ sec. 8, T. 2 N., R. 18 E., 50 miles southeast of Carter, Wyo., on Union Pacific Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age. Sample consisted of a lump taken from prospect September 19, 1914, by A. R. Schultz. The coal bed in this prospect is 3 feet thick. Coal weathered.

20895. Bituminous coal from prospect in NE. ¼ sec. 4, T. 2 N., R. 16 E., 50 miles southeast of Carter, Wyo., on Union Pacific Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age. Roof is shale; floor not seen. Sample consisted of a lump taken from a prospect in September, 1914, by A. R. Schultz. Coal weathered. Section of coal bed in this prospect is as follows:

	Feet.
Shale, carbonaceous	2
Coal	3
	5

VIRGINIA.

The sampling of coals in Virginia was done in connection with a cooperative examination of the southwestern coal fields by the Virginia Geological Survey and the United States Geological Survey.

BUCHANAN COUNTY.

19833. Bituminous coal from Blackey (drift) mine of W. M. Ritter Lumber Co., 1 mile southeast of Blackey station, on Big Sandy & Cumberland Railroad. Coal bed, no name; Carboniferous (Pennsylvanian) age; Pottsville group. Sample slightly wet; cut 450 feet east of mine mouth September 19, 1914, by T. K. Harnsberger. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	½
Sandstone		2¾
Coal (sampled)	2	9
	5	¼

19834. Bituminous coal from same mine as No. 19833. Coal bed, no name; Carboniferous (Pennsylvanian) age; Pottsville group. Sample dry; cut 525

VIRGINIA—Continued.

feet S. 80° E. of mine mouth. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	1¼
Sandstone		2½
Coal (sampled)	2	8¼
	5	0

19735. Bituminous coal from mine of Oliver Elswick, at Big Rock, Va., 15 miles east of Elkhorn City station on Chesapeake & Ohio Railway and Carolina, Clinchfield & Ohio Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Pottsville group. Roof and floor are shale. Sample cut 60 feet N. 70° E. of mine mouth August 11, 1914, by T. K. Harnsberger; represents 3 feet 8½ inches of coal, entire thickness of bed.

19924. Semibituminous coal from Whitewood (drift) mine of C. L. Ritter Lumber Co., at Whitewood, Va., on a railroad owned by the company, 14 miles northwest of Norfolk & Western Railway. Coal bed, no name; Carboniferous (Pennsylvanian) age; Pottsville group. Roof and floor are shale. Sample cut 600 feet southwest of main entrance October 9, 1914, by Clayton Davidson. Section at point sampled is as follows:

	Ft.	in.
Coal, slightly bony (sampled)	3	4
Shale		4
Coal (sampled)		8
	4	4

MONTGOMERY COUNTY.

19357. Semibituminous coal from mine of Plunkett & Wall, 4 miles northwest of Blacksburg, terminus of a branch of Norfolk & Western Railway. Coal bed, Large; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are shale and sandstone. Sample cut down slope 300 feet and northwest 100 feet alongside entry April 28, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal, shaly	1	0
Shale		6
Coal		3
Shale and coal		7
Coal		10
Shale		6
Coal (sampled)	2	2
Shale and coal		8
Coal (sampled)	1	5
Shale and coal		4
Coal (sampled)		3
	8	6

19358. Semibituminous coal from mine of M. C. Slusser, 3½ miles north of Blacksburg, terminus of a branch of Norfolk & Western Railway. Coal bed, Large; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are sandstone. Sample cut in mine 900 feet west on main entry and 25 feet north on side entry April 30, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal	1	2
Shale and coal		6
Shale		8
Coal		5
Shale		2
Coal, crushed		6
Shale		8
Coal (sampled)	2	3
Shale		3
Coal (sampled)	2	3
Shale		3
Coal, crushed (sampled)		10
Shale, bone, and coal		9
Coal, soft, shattered (sampled)	1	6
	12	2

22629. Semibituminous coal from same mine and bed as No. 19358. Roof is shale and floor is sandstone. Sample cut 1,050 feet along main entry and 25 feet northeast along airway May 14, 1915, by J. T. Watson and R. J. Holden. Section of bed at point sampled is as follows:

	Ft.	in.
"Draw slate"	1	6
Coal (sample 22629)	2	4
Coal, shaly		2½
Coal, dull and brittle		5
Coal, bright		8½
Coal, dull and brittle		8½

VIRGINIA—Continued.

	Ft.	in.
Shale		3
Coal, soft (sample 22630)	2	4
Shale		3
Coal, soft and crumbly		11
Shale, containing some coal		9
Coal, bright and soft (sample 22631)	2	2
	12	6½

22630. Semibituminous coal from the same mine and location as No. 22629. Sample represents middle bench of coal.

22631. Semibituminous coal from same mine and location as No. 22629. Sample represents lowest bench of coal.

19359. Semibituminous coal from Clements Hollow mine (abandoned) of Blacksburg Mining & Manufacturing Co., 3½ miles northwest of Blacksburg, terminus of a branch of Norfolk & Western Railway. Coal bed, Small; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are shale and sandstone. Sample weathered; cut in main entry 100 feet from mouth May 1, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		10
Coal, soft, shaly (sampled)		11
Shale		2
Coal, dirty (sampled)		1
Shale, coaly		4
	2	4

19360. Semibituminous coal from Company (slope) mine of Seymour Price & Co., 5 miles northwest of Blacksburg, terminus of a branch of Norfolk & Western Railway. Coal bed, Large; Carboniferous (Mississippian) age; Price sandstone. Roof is shale and sandstone and floor is shale. Sample cut in mine 350 feet down slope and 150 feet northeast along bottom level April 29, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal, soft, shelly	1	0
Shale		6
Coal, soft		3
Shale		5
Coal		6
Coal, soft, dirty		6
Coal		4
Shale		1
Coal		3
Shale		8
Coal (sampled)	2	4
Shale		1
Coal (sampled)		3
Shale		3
Coal		6
Shale		1
Coal (sampled)		8
Shale		1
Coal, sheared (sampled)		8
	9	5

19403. Semianthracite coal from slope mine of Lyken Hill Coal Co., on a branch of Norfolk & Western Railway, 3½ miles northwest of Christianburg. Coal bed, Large; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are shale and sandstone. Sample cut 350 feet along the main slope and east 200 feet on east entry May 7, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal, slightly shaly (sampled)		7
Coal (sampled)		6
Shale		6
Coal (sampled)	1	3
Coal, soft, dirty (sampled)		1½
Coal (sampled)		6
Shale and coal	1	8
Coal	1	2
Shale		7
Coal		9
	7	7½

PULASKI COUNTY.

19431. Semibituminous coal from Parrott (shaft) mine of Pulaski Anthracite Coal Co., at Parrott, on Bluefield division of Norfolk & Western Railway. Coal bed, Large; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are shale. Sample cut in mine 100 feet west of shaft landing April 25, 1914, by Ralph W.

VIRGINIA—Continued.

Howell. Section at point sampled is as follows:

	Ft.	in.
Coal, soft (sampled)		2
Shale		2
Coal (sampled)		9
Shale		3
Coal (sampled)		3
Shale		1
Coal, soft, dirty (sampled)		7
Shale		1
Coal (sampled)		2
Shale		1
Coal (sampled)		4
Shale		6
Coal (sampled)	1	4
Coal and shale		5
Coal (sampled)	1	10
	7	0

20722. Semibituminous coal from Cloyd (drift) mine, 5½ miles northwest of Dublin station, on Norfolk & Western Railway. Coal bed, "Upper"; Carboniferous (Mississippian) age; Price sandstone. Roof and floor are shale passing into sandstone. Sample cut in 125 feet west of mine mouth May 14, 1914, by Ralph W. Howell. Section at point sampled is as follows:

	Ft.	in.
Coal, broken (sampled)		6
Shale and dirty coal		9
Coal, sheared (sampled)		10
Shale and coal		9
Coal (sampled)		7
Shale and bone		4
Coal, soft, dirty (sampled)		10
Coal (sampled)	1	6+
	6	1+

RUSSELL COUNTY.

19484. Bituminous coal from Drill mine of Honaker Lumber Co., at Drill, on Honaker Lumber Co. Railroad. Coal bed, Kennedy; Carboniferous (Pennsylvanian) age; Pottsville group. Roof is shale and floor is sandstone. Sample dry; cut 450 feet northeast of mine mouth, June 5, 1914, by C. M. Bauer; represents 4 feet of coal, entire thickness of bed.

19528. Bituminous coal from Sandy Ridge mine of Sandy Ridge Coal Co., 1 mile south of Drill, on Honaker Lumber Co. Railroad. Coal bed, Kennedy; Carboniferous (Pennsylvanian) age; Pottsville group. Sample cut 150 feet north of mouth of southernmost drift, in room 20 feet to right of entry, June 15, 1914, by C. M. Bauer; represents 2 feet 10 inches of coal, entire thickness of bed.

22345. Bituminous coal from Sandy Ridge mine of Sandy Ridge Coal & Coke Co., half a mile south of Drill, on Honaker Lumber Co. Railroad. Coal bed, Kennedy; Carboniferous (Pennsylvanian) age; Pottsville group. Sample cut 170 feet S. 70° W. of mouth of northernmost drift May 25, 1915, by T. K. Harnsberger; represents 2 feet 9 inches of coal, entire thickness of coal bed.

22346. Bituminous coal from Jackson mine, operated by W. N. Jackson & Bro., 3 miles northwest of Honaker station, on Norfolk & Western Railway. Coal bed, not named; Carboniferous (Pennsylvanian) age; Pottsville group. Sample cut 600 feet northwest of opening May 26, 1915, by T. K. Harnsberger. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	0
Rash (sampled)		⅛
Coal (sampled)	1	9½
Clay		½
Coal (sampled)		7
	3	5⅛

WISE COUNTY.

22277. Bituminous coal from Pardee (No. 1) mine of Blackwood Coal & Coke Co., 1 mile northwest of Pardee station, on Roaring Fork Railroad. Coal bed, Pardee (Limestone or Parsons); Carboniferous (Pennsylvanian) age; Pottsville group. Sample dry; cut in No. 2 right entry off main three-face entry, 2,500 feet N. 15° W. of mine mouth, May 22, 1915, by T. K. Harnsberger. Section at point sampled is as follows:

	Ft.	in.
Coal (roof).		
Coal (sampled)	7	10

VIRGINIA—Continued.

22278. Bituminous coal from same mine and bed as No. 22277. Sample dry; cut at face of main three-face entry, 2,000 feet north of mine mouth, May 22, 1915, by T. K. Harnsberger. Section at point sampled is as follows:

	Ft.	in.
Coal (roof).		
Coal (sampled)	7	8

22279. Bituminous coal from same mine and bed as No. 22277. Sample dry; cut in No. 6 left entry off main entry, 2,500 feet northwest of mine mouth, May 22, 1915, by T. K. Harnsberger. Section at point sampled is as follows:

	Ft.	in.
Coal (roof).		
Coal (sampled)	7	3

22280. Composite of samples 22277 to 22279, inclusive.

WYTHE COUNTY.

20721. Semibituminous coal from prospect pit of Ellison & Johnson, 3 miles north of Max Meadows station, on Norfolk & Western Railway. Coal bed, "Large" or "Upper"; Carboniferous (Mississippian) age; Price sandstone. Roof is sandstone and floor is shale. Sample weathered; cut 10 feet in from mouth May 15, 1914, by Ralph W. Howell; represents 6 feet 8 inches of coal, badly crushed and weathered, entire thickness of bed.

WASHINGTON.

WHATCOM COUNTY.

19722. Anthracite coal from Discovery tunnel of Washington Anthracite Coal Co., in SE. ¼ sec. 29, T. 39 N., R. 7 E., 4 miles south of Glacier, terminus of Bellingham & Northern Railroad, a branch of Chicago, Milwaukee & St. Paul Railway. Coal bed, Tertiary (Eocene) age; Puget group; dips 68° NW. Sample slightly damp; cut at end of 750-foot entry July 31, 1914, by M. R. Campbell. Coal bed varies considerably in thickness, owing to the intense pressure developed when the rocks were folded. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	2	5
Coal, soft, laminated		4
Shale, carbonaceous	1	6
Coal (sampled)	5	10
	10	1

19723. Anthracite coal from same mine as No. 19722. Coal bed, Tertiary (Eocene) age; Puget group. Sample cut 300 feet from mouth of drift July 31, 1914, by M. R. Campbell. Coal slightly weathered and covered with some dirt. Section at point sampled is as follows:

	Ft.	in.
Coal, impure, laminated	1	6
Coal, hard (sampled)	14	5
Coal, impure, laminated	2	1
	18	0

19724. Anthracite coal from Smith tunnel of Washington Anthracite Coal Co., in SE. ¼ sec. 30, T. 39 N., R. 7 E., 4 miles south of Glacier, terminus of Bellingham & Northern Railroad, a branch of Chicago, Milwaukee & St. Paul Railway. Coal bed, Tertiary (Eocene) age; Puget group; dips about 30° NE. Sample weathered; cut in first right entry 200 feet from mouth of tunnel August 1, 1914, by M. R. Campbell. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	5	6
Coal, soft, laminated	2	6
	8	0

19725. Semianthracite (?) coal from prospect in SE. ¼ sec. 24, T. 39 N., R. 6 E., 3 miles southwest of Glacier, terminus of Bellingham & Northern Railroad, a branch of Chicago, Milwaukee & St. Paul Railway. Coal bed, Tertiary (Eocene) age; Puget group; dips about 51° NE. Sample weathered; cut from east end of drift, 20 feet from mouth, August 2, 1914, by M. R. Campbell. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)	5	9
Bone		11
Coal, soft, laminated	2	7+
	9	3+

19726. Semianthracite (?) coal from open-cut prospect in SW. ¼ sec. 24, T. 39

WASHINGTON—Continued.

N., R. 6 E., 3 miles southwest of Glacier, terminus of Bellingham & Northern Railroad, a branch of Chicago, Milwaukee & St Paul Railway. Coal bed. Tertiary (Eocene) age; dips 30°–40° N.; poorly exposed. Sample badly weathered, crushed, and squeezed; taken from open cut August 2, 1914, by M. R. Campbell; represents about 3 feet of coal.

WEST VIRGINIA.

CLAY COUNTY.

21816. Bituminous coal from Rich Run (drift) mine of Elk River Coal & Lumber Co., at Widen, terminus of Buffalo Creek & Gauley Railroad. Coal bed, No. 5 Block; Carboniferous (Pennsylvanian) age; Allegheny formation. Roof is shale and floor is clay. Sample cut at face of No. 1 east entry off No. 5½ entry, about 2,000 feet S. 60° E. of mine mouth and about 800 feet from nearest outcrop, April 9, 1915, by E. Russell Lloyd. Section at point sampled is as follows:

	Ft.	in.
Coal with bright luster (sampled)		11
Shale and bone		6
Coal (sampled)	4	4
	5	9

21817. Bituminous coal from same mine and bed as No. 21816. Roof is sandstone and floor is clay. Sample cut from room 15 off No. 2 right entry off No. 5½ entry, 1,200 feet southwest of mine mouth and about 150 feet from nearest outcrop, April 9, 1915, by E. Russell Lloyd. Section at point sampled is as follows:

	Ft.	in.
Coal (sampled)		6½
Mineral charcoal (sampled)		½
Coal (sampled)		5½
Shale		5
Coal (sampled)	3	7½
Shale		1½
Coal (sampled)		9
	5	11½

21818. Composite of samples 21816 and 21817.

21892. Bituminous coal from same mine and bed as No. 21816. Roof is shale and floor is clay. Sample cut at same place as No. 21816, April 9, 1915, by E. Russell Lloyd. Section of bed at point sampled is as follows:

	Ft.	in.
Coal with bright luster (sampled)		11
Shale and bone		6
Coal	4	4
	5	9

NICHOLAS COUNTY.

21819. Bituminous coal from local mine operated by Edward McClung at Kirkwood, 16 miles southwest of Camden, on Baltimore & Ohio Railroad. Coal bed, No. 2 or Gas (?); Carboniferous (Pennsylvanian) age; Kanawha formation. Roof is shale and floor is clay. Sample fresh; cut at face of entry 60 feet S. 7° E. of mouth, April 8, 1915, by E. Russell Lloyd. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	5½
Bone		1
Coal (sampled)	1	10
	3	4½

21820. Bituminous coal from local mine operated by George Donaldson at Muddlety, about 20 miles southwest of Camden, on Baltimore & Ohio Railroad. Coal bed, No. 1 or Eagle (?); Carboniferous (Pennsylvanian) age; Kanawha formation. Roof is shale and floor is clay. Sample cut at face of entry about 200 feet S. 50° E. of mine mouth, April 7, 1915, by E. Russell Lloyd. Section of bed at point sampled is as follows:

	Ft.	in.
Coal (sampled)	1	1
Bone		½
Coal		1½
Shale		5
Coal (sampled)		6
Bone		1
Coal (sampled)	1	4
Shale		1½
Coal (sampled)		4½
	4	1

COAL ANALYSES.

[Made by the Bureau of Mines; A. C. Fieldner, chemist in charge. For description of samples, see pp. 256-328.]

COLORADO.

ELBERT COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19902	23.5	A	33.1	[b] 25.6	25.6	15.66	0.44	6.20	36.78	0.70	40.22	3,415	6,150
		B	12.5	33.5	33.5	20.48	.57	4.68	48.10	.91	25.26	4,465	8,040
		C	....	38.3	38.3	23.41	.66	3.77	54.98	1.05	16.13	5,105	9,190
		D	....	50.0	50.0	....	.86	4.92	71.79	1.37	21.06	6,665	12,000

LA PLATA COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20268	11.5	A	15.7	31.7	44.5	8.06	0.58	5.65	59.59	1.19	24.93	5,705	10,270
		B	4.8	35.8	50.3	9.10	.65	4.95	67.30	1.34	16.66	6,445	11,600
		C	....	37.6	52.8	9.57	.69	4.63	70.72	1.42	12.97	6,770	12,190
		D	....	41.6	58.4	....	.76	5.12	78.20	1.57	14.35	7,490	13,480

MONTEZUMA COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20267	8.7	A	12.1	37.7	44.1	6.07	0.59	5.96	64.41	1.41	21.56	6,330	11,390
		B	3.7	41.3	48.3	6.65	.65	5.47	70.53	1.54	15.16	6,930	12,480
		C	....	42.9	50.2	6.91	.67	5.26	73.28	1.60	12.28	7,200	12,960
		D	....	46.1	53.9	....	.72	5.65	78.72	1.72	13.19	7,735	13,930
20498	6.2	A	8.5	39.2	47.0	5.33	.99	5.97	69.99	1.31	16.41	6,975	12,560
		B	2.4	41.8	50.1	5.68	1.06	5.62	74.60	1.40	11.64	7,435	13,390
		C	....	42.9	51.3	5.82	1.08	5.49	76.46	1.43	9.72	7,620	13,720
		D	....	45.5	54.5	....	1.15	5.83	81.19	1.52	10.31	8,090	14,570
20500	4.6	A	7.0	38.3	50.2	4.47	.61	5.70	72.57	1.33	15.32	7,185	12,940
		B	2.5	40.2	52.6	4.68	.64	5.44	76.05	1.39	11.80	7,530	13,550
		C	....	41.2	54.0	4.80	.66	5.29	78.01	1.43	9.81	7,725	13,910
		D	....	43.3	56.7	....	.69	5.56	81.94	1.50	10.31	8,115	14,610
20499	3.2	A	5.5	38.3	47.3	8.85	.77	5.59	69.92	1.33	13.54	6,970	12,550
		B	2.3	39.6	48.9	9.15	.80	5.41	72.26	1.37	11.01	7,205	12,970
		C	....	40.6	50.0	9.37	.81	5.27	74.00	1.41	9.14	7,375	13,280
		D	....	44.8	55.2	....	.89	5.81	81.65	1.56	10.09	8,140	14,650

MONTANA.

CHOUTEAU COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.[a]	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19790	7.2	A	18.1	[b] 29.3	41.3	11.33	0.81	5.61	53.21	1.20	27.84	5,065	9,120
		B	11.8	31.5	44.5	12.20	.87	5.18	57.32	1.29	23.14	5,455	9,820
		C	....	35.8	50.4	13.84	.99	4.39	65.01	1.47	14.30	6,185	11,140
		D	....	41.5	58.5	....	1.15	5.10	75.45	1.71	16.59	7,180	12,930
[c] 19795	4.1	A	17.5	[b] 30.1	41.2	11.17	.61	5.62	54.42	1.11	27.07	5,175	9,320
		B	13.9	31.5	43.0	11.65	.64	5.38	56.75	1.16	24.42	5,395	9,720
		C	....	36.6	49.9	13.54	.74	4.46	65.95	1.35	13.96	6,270	11,290
		D	....	42.3	57.7	....	.86	5.16	76.28	1.56	16.14	7,255	13,060

[a] See p. 253.

[b] Volatile matter determined by the modified official method. (See Bureau of Mines Bull. 22, p. 29, 1913.)

[c] Coal slightly weathered.

MONTANA—Continued.

DAWSON COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19923	19.2	A	28.3	26.5	33.6	11.6	0.45	......	......	......	......	4,090	7,360
		B	11.2	32.8	41.7	14.3	.56	......	......	......	......	5,060	9,110
		C	......	36.9	46.9	16.2	.63	......	......	......	......	5,705	10,270
		D	......	44.0	56.0	......	.75	......	......	......	......	6,805	12,250
FALLON COUNTY.													
20370	34.3	A	41.3	[a]24.6	26.9	7.2	0.62	......	......	......	......	3,440	6,190
		B	10.6	37.5	40.9	11.0	.95	......	......	......	......	5,240	9,430
		C	......	42.0	45.8	12.2	1.06	......	......	......	......	5,860	10,550
		D	......	47.8	52.2	......	1.21	......	......	......	......	6,680	12,020
20372	33.5	A	39.0	[a]22.6	23.9	14.5	1.60	......	......	......	......	3,110	5,600
		B	8.4	34.0	35.9	21.7	2.41	......	......	......	......	4,680	8,420
		C	......	37.1	39.2	23.7	2.62	......	......	......	......	5,105	9,190
		D	......	48.7	51.3	......	3.44	......	......	......	......	6,690	12,050
FERGUS COUNTY.													
20000	14.4	A	22.8	[a]27.7	37.7	11.77	0.82	5.96	49.34	1.08	31.03	4,710	8,480
		B	9.8	32.3	44.1	13.75	.96	5.09	57.64	1.26	21.30	5,500	9,900
		C	......	35.8	48.9	15.25	1.06	4.44	63.92	1.40	13.93	6,100	10,980
		D	......	42.3	57.7	......	1.25	5.24	75.41	1.65	16.45	7,200	12,960
MUSSELSHELL COUNTY.													
19784	4.5	A	10.4	[a]31.1	43.5	15.05	1.77	5.29	57.38	1.41	19.10	5,680	10,220
		B	6.2	32.6	45.5	15.75	1.85	5.01	60.07	1.48	15.84	5,945	10,700
		C	......	34.7	48.5	16.79	1.97	4.62	64.02	1.57	11.03	6,335	11,400
		D	......	41.7	58.3	......	2.37	5.55	76.94	1.89	13.25	7,615	13,700
19785	4.2	A	10.4	[a]29.6	43.9	16.1	1.73	......	......	......	......	5,610	10,100
		B	6.6	30.9	45.8	16.7	1.81	......	......	......	......	5,855	10,540
		C	......	33.1	49.0	17.9	1.93	......	......	......	......	6,265	11,280
		D	......	40.3	59.7	......	2.35	......	......	......	......	7,630	13,740
NEW MEXICO.													
McKINLEY COUNTY.													
19131	4.8	A	12.5	38.9	39.4	9.17	0.43	5.89	60.85	1.09	22.57	6,000	10,800
		B	8.2	40.8	41.4	9.63	.45	5.63	63.93	1.15	19.21	6,305	11,350
		C	......	44.4	45.1	10.49	.49	5.15	69.58	1.25	13.04	6,865	12,350
		D	......	49.7	50.3	......	.55	5.75	77.73	1.40	14.57	7,665	13,800
19132	5.7	A	14.1	39.7	42.2	4.00	.58	6.13	64.15	1.16	23.98	6,285	11,320
		B	8.9	42.1	44.8	4.24	.62	5.83	68.04	1.23	20.04	6,665	12,000
		C	......	46.2	49.1	4.65	.67	5.32	74.64	1.35	13.37	7,315	13,170
		D	......	48.5	51.5	......	.70	5.58	78.28	1.42	14.02	7,670	13,810
19133	6.1	A	14.0	39.5	41.1	5.4	.49	......	......	......	......	6,260	11,260
		B	8.4	42.0	43.8	5.8	.52	......	......	......	......	6,660	11,990
		C	......	45.9	47.8	6.3	.57	......	......	......	......	7,275	13,100
		D	......	49.0	51.0	......	.61	......	......	......	......	7,765	13,980
19134	5.3	A	12.4	39.1	39.5	9.0	.44	......	......	......	......	6,100	10,980
		B	7.5	41.3	41.7	9.5	.47	......	......	......	......	6,440	11,600
		C	......	44.6	45.1	10.3	.50	......	......	......	......	6,965	12,540
		D	......	49.7	50.3	......	.56	......	......	......	......	7,765	13,960
19135	5.7	A	13.2	39.1	40.5	7.21	.45	6.04	62.73	1.13	22.44	6,165	11,100
		B	7.9	41.5	42.9	7.65	.48	5.74	66.51	1.20	18.42	6,535	11,770
		C	......	45.1	46.6	8.31	.52	5.26	72.26	1.30	12.35	7,100	12,780
		D	......	49.2	50.8	......	.57	5.74	78.81	1.42	13.46	7,745	13,940

[a] Volatile matter determined by the modified official method.

NEW MEXICO—Continued.

McKINLEY COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19136	4.6	A	11.8	38.1	39.7	10.40	0.65	5.71	61.57	1.14	20.53	6,055	10,900
		B	7.6	39.9	41.6	10.90	.68	5.45	64.50	1.19	17.28	6,345	11,420
		C	....	43.2	45.0	11.79	.74	4.99	69.80	1.29	11.39	6,865	12,360
		D	....	49.0	51.0	....	.84	5.66	79.13	1.46	12.91	7,785	14,010
19137	5.5	A	14.1	39.2	41.9	4.8	.49	....	....	....	....	6,280	11,300
		B	9.1	41.5	44.3	5.1	.52	....	....	....	....	6,645	11,960
		C	....	45.6	48.8	5.6	.57	....	....	....	....	7,305	13,150
		D	....	48.3	51.7	....	.60	....	....	....	....	7,745	13,940
19138	6.4	A	15.8	38.0	43.1	3.14	.45	6.28	64.08	1.11	24.94	6,275	11,300
		B	10.1	40.6	46.0	3.35	.48	5.95	68.45	1.19	20.58	6,710	12,080
		C	....	45.1	51.2	3.73	.53	5.37	76.12	1.32	12.93	7,460	13,430
		D	....	46.9	53.1	....	.55	5.58	79.07	1.37	13.43	7,750	13,950
19139	5.5	A	13.5	37.8	42.5	6.24	.36	5.95	63.37	1.10	22.98	6,190	11,140
		B	8.5	39.9	45.0	6.60	.38	5.65	67.03	1.16	19.18	6,545	11,780
		C	....	43.6	49.2	7.21	.42	5.14	73.26	1.27	12.70	7,155	12,880
		D	....	47.0	53.0	....	.45	5.54	78.95	1.37	13.69	7,710	13,880
19140	5.7	A	13.9	39.0	40.6	6.5	.47	....	....	....	....	6,165	11,100
		B	8.7	41.3	43.1	6.9	.50	....	....	....	....	6,535	11,770
		C	....	45.3	47.2	7.5	.55	....	....	....	....	7,160	12,890
		D	....	48.9	51.1	....	.59	....	....	....	....	7,745	13,940
19162	4.0	A	11.4	39.9	42.2	6.5	.75	....	....	....	....	6,465	11,640
		B	7.7	41.5	44.0	6.8	.78	....	....	....	....	6,735	12,120
		C	....	45.0	47.7	7.3	.85	....	....	....	....	7,295	13,140
		D	....	48.5	51.5	....	.92	....	....	....	....	7,875	14,180
19163	3.4	A	10.6	40.6	44.4	4.40	.59	5.95	68.16	1.11	19.79	6,725	12,100
		B	7.4	42.0	46.0	4.55	.61	5.77	70.56	1.15	17.36	6,960	12,530
		C	....	45.4	49.7	4.92	.66	5.33	76.22	1.24	11.63	7,520	13,530
		D	....	47.7	52.3	....	.69	5.61	80.16	1.30	12.24	7,905	14,230
19213	7.6	A	12.7	36.4	43.4	7.47	.72	5.78	64.18	1.10	20.75	6,240	11,230
		B	5.5	39.5	46.9	8.08	.78	5.35	69.44	1.19	15.16	6,750	12,150
		C	....	41.7	49.7	8.56	.82	5.01	73.52	1.26	10.83	7,145	12,870
		D	....	45.7	54.3	....	.90	5.48	80.40	1.38	11.84	7,815	14,070
19217	9.3	A	15.2	38.1	40.6	6.1	.58	....	....	....	....	6,085	10,950
		B	6.5	42.0	44.8	6.7	.64	....	....	....	....	6,705	12,070
		C	....	44.9	47.9	7.2	.68	....	....	....	....	7,175	12,920
		D	....	48.4	51.6	....	.73	....	....	....	....	7,730	13,910
19218	9.0	A	14.8	35.4	38.0	11.8	.43	....	....	....	....	5,640	10,150
		B	6.3	38.9	41.8	13.0	.47	....	....	....	....	6,200	11,160
		C	....	41.6	44.5	13.9	.50	....	....	....	....	6,615	11,910
		D	....	48.3	51.7	....	.58	....	....	....	....	7,685	13,830
19219	8.2	A	14.3	38.6	40.3	6.8	.40	....	....	....	....	6,085	10,950
		B	6.6	42.1	43.9	7.4	.44	....	....	....	....	6,630	11,930
		C	....	45.1	46.9	8.0	.47	....	....	....	....	7,095	12,770
		D	....	49.0	51.0	....	.51	....	....	....	....	7,710	13,880
19220	8.8	A	14.8	37.2	39.7	8.30	.50	6.02	60.78	1.07	23.33	5,945	10,700
		B	6.5	40.9	43.5	9.10	.55	5.53	66.67	1.17	16.98	6,525	11,740
		C	....	43.7	46.6	9.74	.59	5.14	71.31	1.26	11.96	6,975	12,560
		D	....	48.4	51.6	....	.65	5.69	79.00	1.40	13.26	7,730	13,910
19221	10.6	A	15.4	38.2	41.3	5.11	.92	6.25	62.95	1.13	23.64	6,185	11,130
		B	5.4	42.7	46.2	5.72	1.03	5.67	70.40	1.26	15.92	6,915	12,450
		C	....	45.1	48.9	6.04	1.09	5.37	74.40	1.34	11.76	7,310	13,160
		D	....	48.0	52.0	....	1.16	5.72	79.18	1.43	12.51	7,780	14,000
19222	10.0	A	16.2	38.1	40.8	4.9	.61	....	....	....	....	6,110	11,000
		B	6.9	42.3	45.4	5.4	.68	....	....	....	....	6,785	12,220
		C	....	45.4	48.7	5.9	.73	....	....	....	....	7,285	13,120
		D	....	48.2	51.8	....	.78	....	....	....	....	7,740	13,930
19223	5.9	A	10.6	40.9	41.4	7.1	.79	....	....	....	....	6,395	11,510
		B	5.0	43.5	44.0	7.5	.84	....	....	....	....	6,795	12,230
		C	....	45.7	46.4	7.9	.88	....	....	....	....	7,155	12,880
		D	....	49.7	50.3	....	.96	....	....	....	....	7,770	13,990

NEW MEXICO—Continued.

McKINLEY COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19286	6.7	A	14.6	38.8	40.9	5.7	0.60	....	....	....	....	6,130	11,030
		B	8.4	41.6	43.9	6.1	.64	....	....	....	....	6,575	11,830
		C	....	45.4	47.9	6.7	.70	....	....	....	....	7,175	12,920
		D	....	48.7	51.3	....	.75	....	....	....	....	7,690	13,840
19287	7.5	A	15.0	38.1	43.6	3.3	.53	....	....	....	....	6,305	11,350
		B	8.0	41.2	47.2	3.6	.57	....	....	....	....	6,820	12,270
		C	....	44.8	51.3	3.9	.62	....	....	....	....	7,415	13,350
		D	....	46.6	53.4	....	.65	....	....	....	....	7,715	13,890
19288	8.5	A	16.0	38.1	41.3	4.6	.85	....	....	....	....	6,100	10,980
		B	8.3	41.6	45.1	5.0	.93	....	....	....	....	6,660	11,990
		C	....	45.3	49.2	5.5	1.01	....	....	....	....	7,265	13,070
		D	....	47.9	52.1	....	1.07	....	....	....	....	7,685	13,830

SOCORRO COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
[a] 20007	18.5	A	25.9	[b] 30.3	34.7	9.07	0.39	5.65	46.45	0.91	37.53	4,125	7,430
		B	9.1	37.2	42.6	11.13	.48	4.40	57.00	1.12	25.87	5,065	9,120
		C	....	40.9	46.9	12.24	.53	3.74	62.69	1.23	19.57	5,570	10,030
		D	....	46.6	53.4	....	.60	4.26	71.44	1.40	22.30	6,345	11,430

NORTH DAKOTA.

MORTON COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
[a] 19786	24.9	A	36.1	[b] 27.7	30.4	5.8	0.41	....	....	....	....	3,875	6,980
		B	14.9	36.9	40.4	7.8	.54	....	....	....	....	5,165	9,300
		C	....	43.3	47.5	9.2	.64	....	....	....	....	6,065	10,920
		D	....	47.7	52.3	....	.70	....	....	....	....	6,680	12,020
19801	31.5	A	38.6	[b] 26.8	26.7	7.9	.66	....	....	....	....	3,585	6,450
		B	10.4	39.1	39.0	11.5	.97	....	....	....	....	5,230	9,420
		C	....	43.7	43.5	12.8	1.07	....	....	....	....	5,835	10,500
		D	....	50.1	49.9	....	1.23	....	....	....	....	6,695	12,050
20033	32.7	A	38.5	27.6	26.6	7.28	1.31	7.03	39.22	0.60	44.56	3,725	6,700
		B	8.6	41.0	39.6	10.83	1.95	5.04	58.31	.89	22.98	5,535	9,970
		C	....	44.9	43.3	11.84	2.13	4.47	63.79	.98	16.79	6,055	10,900
		D	....	50.9	49.1	....	2.42	5.07	72.36	1.11	19.04	6,870	12,360

OHIO.

BELMONT COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20174	2.2	A	4.3	35.3	44.2	16.22	3.53	4.98	64.10	1.20	9.97	6,445	11,610
		B	2.2	36.1	45.1	16.58	3.61	4.84	65.52	1.23	8.22	6,590	11,860
		C	....	36.9	46.1	16.95	3.69	4.70	66.98	1.25	6.43	6,735	12,130
		D	....	44.4	55.6	....	4.44	5.66	80.65	1.50	7.75	8,110	14,600
20176	2.4	A	4.3	39.0	45.5	11.21	3.65	5.31	68.17	1.20	10.46	6,890	12,400
		B	2.0	39.9	46.6	11.48	3.74	5.16	69.84	1.23	8.55	7,060	12,710
		C	....	40.7	47.6	11.72	3.81	5.05	71.26	1.25	6.91	7,205	12,970
		D	....	46.1	53.9	....	4.32	5.72	80.72	1.42	7.82	8,160	14,690
20187	2.3	A	4.1	42.7	43.9	9.3	4.46	....	....	....	....	7,075	12,730
		B	1.9	43.7	44.9	9.5	4.56	....	....	....	....	7,240	13,030
		C	....	44.6	45.7	9.7	4.65	....	....	....	....	7,380	13,280
		D	....	49.4	50.6	....	5.15	....	....	....	....	8,175	14,710
20188	1.7	A	3.7	43.3	44.4	8.6	4.45	....	....	....	....	7,195	12,950
		B	2.0	44.0	45.2	8.8	4.53	....	....	....	....	7,320	13,170
		C	....	44.9	46.1	9.0	4.62	....	....	....	....	7,470	13,450
		D	....	49.3	50.7	....	5.07	....	....	....	....	8,205	14,770

[a] Weathered.

[b] Moisture determined by modified official method.

OHIO—Continued.

BELMONT COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20189	2.0	A	3.9	43.1	43.9	9.07	4.36	5.46	69.97	1.27	9.87	7,130	12,840
		B	1.9	44.0	44.8	9.25	4.45	5.35	71.39	1.30	8.26	7,275	13,100
		C	....	44.8	45.8	9.44	4.54	5.23	72.80	1.32	6.67	7,420	13,360
		D	....	49.5	50.5	....	5.01	5.77	80.39	1.46	7.37	8,195	14,750
20230	2.0	A	3.7	41.0	45.8	9.5	4.57	....	....	....	....	7,090	12,760
		B	1.8	41.8	46.7	9.7	4.66	....	....	....	....	7,230	13,010
		C	....	42.6	47.5	9.9	4.75	....	....	....	....	7,365	13,250
		D	....	47.3	52.7	....	5.27	....	....	....	....	8,170	14,700
20234	2.3	A	4.4	37.1	43.1	15.4	2.90	....	....	....	....	6,475	11,660
		B	2.2	37.9	44.1	15.8	2.97	....	....	....	....	6,625	11,930
		C	....	38.8	45.0	16.2	3.03	....	....	....	....	6,775	12,190
		D	....	46.3	53.7	....	3.61	....	....	....	....	8,080	14,540
20236	2.4	A	4.6	36.8	44.2	14.4	2.59	....	....	....	....	6,575	11,830
		B	2.2	37.7	45.3	14.8	2.65	....	....	....	....	6,735	12,120
		C	....	38.6	46.3	15.1	2.71	....	....	....	....	6,890	12,400
		D	....	45.5	54.5	....	3.19	....	....	....	....	8,120	14,610
20237	1.6	A	3.5	37.2	41.5	17.8	4.05	....	....	....	....	6,395	11,510
		B	1.9	37.8	42.2	18.1	4.12	....	....	....	....	6,500	11,700
		C	....	38.5	43.0	18.5	4.20	....	....	....	....	6,630	11,930
		D	....	47.2	52.8	....	5.15	....	....	....	....	8,130	14,630
20238	2.3	A	4.1	33.7	41.2	21.00	2.86	4.76	59.93	1.09	10.36	6,010	10,820
		B	1.8	34.5	42.2	21.50	2.93	4.61	61.37	1.12	8.47	6,155	11,080
		C	....	35.1	43.0	21.89	2.98	4.49	62.48	1.14	7.02	6,270	11,280
		D	....	45.0	55.0	....	3.81	5.75	79.99	1.46	8.99	8,025	14,440
20241	2.5	A	4.5	36.6	44.2	14.75	3.02	5.10	65.32	1.16	10.65	6,555	11,800
		B	2.0	37.6	45.3	15.13	3.10	4.94	67.02	1.19	8.62	6,725	12,100
		C	....	38.3	46.3	15.44	3.16	4.81	68.37	1.21	7.01	6,860	12,350
		D	....	45.3	54.7	....	3.74	5.69	80.85	1.43	8.29	8,110	14,600
20775	2.6	A	4.7	34.2	45.8	15.34	2.85	4.95	63.71	1.33	11.82	6,480	11,660
		B	2.1	35.1	47.0	15.75	2.93	4.79	65.42	1.37	9.74	6,655	11,980
		C	....	35.9	48.0	16.10	2.99	4.65	66.85	1.40	8.01	6,800	12,240
		D	....	42.8	57.2	....	3.56	5.54	79.68	1.67	9.55	9,105	14,590

GUERNSEY COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20178	2.2	A	4.4	41.1	45.8	8.74	4.85	5.37	69.30	1.26	10.48	7,060	12,710
		B	2.2	42.1	46.8	8.93	4.96	5.24	70.83	1.29	8.75	7,215	12,990
		C	....	43.0	47.9	9.14	5.07	5.11	72.46	1.32	6.90	7,385	13,290
		D	....	47.4	52.6	....	5.58	5.62	79.75	1.45	7.60	8,125	14,630
20243	2.5	A	4.3	40.2	45.1	10.39	3.75	5.37	68.30	1.50	10.69	6,940	12,490
		B	1.9	41.2	46.2	10.65	3.84	5.23	70.02	1.54	8.72	7,115	12,810
		C	....	42.0	47.1	10.86	3.92	5.11	71.39	1.57	7.15	7,255	13,060
		D	....	47.2	52.8	....	4.40	5.73	80.09	1.76	8.02	8,140	14,650
20245	4.2	A	6.9	34.1	53.3	5.7	.84	....	....	....	....	7,105	12,790
		B	2.8	35.6	55.6	6.0	.88	....	....	....	....	7,410	13,340
		C	....	36.6	57.2	6.2	.90	....	....	....	....	7,630	13,730
		D	....	39.0	61.0	....	.96	....	....	....	....	8,130	14,640
20246	3.6	A	6.2	36.2	52.3	5.3	.88	....	....	....	....	7,225	13,000
		B	2.7	37.5	54.3	5.5	.91	....	....	....	....	7,495	13,490
		C	....	38.6	55.8	5.6	.94	....	....	....	....	7,705	13,870
		D	....	40.9	59.1	....	1.00	....	....	....	....	8,170	14,700
20247	3.9	A	6.5	35.4	52.6	5.53	.88	5.49	73.42	1.37	13.31	7,190	14,940
		B	2.7	36.9	54.7	5.75	.92	5.27	76.39	1.43	10.24	7,480	13,470
		C	....	37.9	56.2	5.91	.94	5.10	78.51	1.46	8.08	7,690	13,840
		D	....	40.2	59.8	....	1.00	5.42	83.44	1.55	8.59	8,170	14,710
20261	3.2	A	5.4	35.8	50.8	8.0	1.64	....	....	....	....	7,100	12,780
		B	2.2	37.0	52.5	8.3	1.69	....	....	....	....	7,340	13,210
		C	....	37.8	53.7	8.5	1.73	....	....	....	....	7,505	13,510
		D	....	41.4	58.6	....	1.89	....	....	....	....	8,205	14,770

OHIO—Continued.

GUERNSEY COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20262	4.1	A	6.4	33.7	52.1	7.8	2.16					7,015	12,630
		B	2.4	35.1	54.4	8.1	2.25					7,315	13,170
		C		36.0	55.7	8.3	2.30					7,495	13,490
		D		39.2	60.8		2.51					8,175	14,720
20263	3.7	A	6.0	34.2	52.0	7.83	1.98	5.38	71.38	1.32	12.11	7,065	12,720
		B	2.4	35.5	54.0	8.13	2.06	5.16	74.12	1.37	9.16	7,340	13,210
		C		36.4	55.3	8.33	2.11	5.01	75.93	1.40	7.22	7,520	13,530
		D		39.7	60.3		2.30	5.47	82.83	1.53	7.87	8,200	14,760
20264	3.8	A	6.1	35.2	51.8	6.9	1.62					7,075	12,740
		B	2.4	36.6	53.8	7.2	1.68					7,355	13,240
		C		37.5	55.1	7.4	1.72					7,535	13,570
		D		40.5	59.5		1.86					8,135	14,650
20265	3.4	A	6.0	35.7	50.4	7.9	2.15					7,035	12,660
		B	2.6	37.0	52.2	8.2	2.23					7,285	13,110
		C		38.0	53.6	8.4	2.29					7,480	13,460
		D		41.5	58.5		2.50					8,170	14,700
20266	3.6	A	6.1	35.0	51.6	7.33	1.95	5.37	71.24	1.39	12.72	7,060	12,710
		B	2.5	36.4	53.5	7.60	2.02	5.16	73.91	1.44	9.87	7,325	13,190
		C		37.3	54.9	7.80	2.08	5.00	75.84	1.48	7.80	7,520	13,530
		D		40.5	59.5		2.26	5.42	82.26	1.61	8.45	8,155	14,680
JEFFERSON COUNTY.													
15394	1.4	A	3.5	38.0	51.1	7.44	3.09	5.43	73.39	1.46	9.19	7,380	13,290
		B	2.1	38.5	51.8	7.55	3.13	5.35	74.43	1.48	8.06	7,485	13,480
		C		39.4	52.9	7.71	3.20	5.22	76.05	1.51	6.31	7,650	13,770
		D		42.7	57.3		3.47	5.66	82.40	1.64	6.83	8,290	14,920
15395	1.7	A	3.7	38.0	49.6	8.75	2.82	5.32	71.76	1.39	9.96	7,285	13,110
		B	2.0	38.6	50.5	8.90	2.87	5.22	73.00	1.41	8.60	7,410	13,340
		C		39.4	51.5	9.09	2.93	5.10	74.51	1.44	6.93	7,560	13,610
		D		43.4	56.6		3.22	5.61	81.96	1.58	7.63	8,320	14,970
15442	1.6	A	3.4	38.0	51.6	6.97	2.71	5.40	73.31	1.46	10.15	7,440	13,390
		B	1.8	38.6	52.5	7.08	2.75	5.31	74.50	1.49	8.87	7,560	13,610
		C		39.3	53.5	7.21	2.80	5.20	75.88	1.51	7.40	7,700	13,860
		D		42.4	57.6		3.02	5.60	81.78	1.63	7.97	8,295	14,930
15446	2.4	A	4.7	36.6	50.8	7.89	2.80	5.28	71.72	1.35	10.96	7,195	12,950
		B	2.3	37.5	52.1	8.08	2.87	5.13	73.49	1.38	9.05	7,370	13,270
		C		38.4	53.3	8.28	2.94	4.99	75.23	1.42	7.14	7,545	13,580
		D		41.9	58.1		3.21	5.44	82.02	1.55	7.78	8,225	14,810
15565	2.3	A	4.1	38.0	50.2	7.70	3.84	5.23	71.69	1.39	10.15	7,230	13,010
		B	1.8	38.9	51.4	7.88	3.93	5.10	73.38	1.42	8.29	7,400	13,320
		C		39.6	52.4	8.03	4.00	4.97	74.77	1.45	6.78	7,540	13,570
		D		43.1	56.9		4.35	5.40	81.30	1.58	7.37	8,130	14,760
MONROE COUNTY.													
20259	2.7	A	4.9	35.9	43.9	15.32	3.96	4.87	63.59	1.19	11.07	6,410	11,540
		B	2.2	36.9	45.1	15.75	4.07	4.70	65.36	1.22	8.90	6,590	11,860
		C		37.8	46.1	16.10	4.16	4.55	66.83	1.25	7.11	6,740	12,130
		D		45.0	55.0		4.96	5.42	79.65	1.49	8.48	8,030	14,460

OHIO—Continued.

NOBLE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20185	2.1	A	4.2	38.4	44.8	12.62	3.61	5.22	66.87	1.20	10.48	6,740	12,130
		B	2.1	39.2	45.8	12.88	3.69	5.09	68.27	1.23	8.84	6,880	12,380
		C	....	40.1	46.7	13.17	3.77	4.97	69.76	1.25	7.08	7,030	12,650
		D	....	46.2	53.8	....	4.34	5.72	80.34	1.44	8.16	8,095	12,570
20235	2.4	A	4.5	39.6	45.6	10.32	4.12	5.27	68.00	1.17	11.12	6,845	12,320
		B	2.1	40.6	46.7	10.58	4.22	5.12	69.69	1.20	9.19	7,015	12,630
		C	....	41.4	47.8	10.81	4.32	5.00	71.22	1.23	7.42	7,170	12,910
		D	....	46.5	53.5	....	4.84	5.61	79.85	1.38	8.32	8,040	14,470
20240	1.9	A	3.6	41.5	44.4	10.53	4.87	5.25	68.15	1.11	10.09	6,945	12,510
		B	1.8	42.3	45.2	10.73	4.96	5.14	69.45	1.13	8.59	7,080	12,740
		C	....	43.1	46.0	10.92	5.05	5.03	70.67	1.15	7.18	7,205	12,970
		D	....	48.4	51.6	....	5.67	5.65	79.33	1.29	8.06	8,085	14,560

OKLAHOMA.

CRAIG COUNTY.

20715	2.9	A	4.9	35.4	48.0	11.7	5.76	....	....	....	....	6,935	12,480
		B	2.0	36.4	49.5	12.1	5.93	....	....	....	....	7,145	12,860
		C	....	37.2	50.5	12.3	6.06	....	....	....	....	7,290	13,120
		D	....	42.4	57.6	....	6.91	....	....	....	....	8,315	14,970
20716	2.5	A	4.1	37.4	48.3	10.17	6.08	5.33	69.76	1.39	7.27	7,175	12,920
		B	1.7	38.4	49.5	10.43	6.24	5.18	71.57	1.43	5.15	7,360	13,250
		C	....	39.0	50.4	10.61	6.34	5.08	72.77	1.45	3.75	7,485	13,470
		D	....	43.7	56.3	....	7.09	5.68	81.41	1.62	4.20	8,375	15,070
20717	2.4	A	4.1	40.3	45.5	10.1	6.55	....	....	....	....	7,170	12,910
		B	1.8	41.3	46.6	10.3	6.71	....	....	....	....	7,345	13,230
		C	....	42.1	47.4	10.5	6.83	....	....	....	....	7,480	13,460
		D	....	47.0	53.0	....	7.63	....	....	....	....	8,355	15,040
20718	4.1	A	5.7	38.3	45.9	10.1	6.02	....	....	....	....	6,980	12,570
		B	1.7	39.9	47.9	10.5	6.28	....	....	....	....	7,280	13,110
		C	....	40.6	48.7	10.7	6.38	....	....	....	....	7,410	13,330
		D	....	45.4	54.6	....	7.14	....	....	....	....	8,295	14,930

ROGERS COUNTY.

20714	3.8	A	6.1	38.3	47.4	8.2	3.84	....	....	....	....	7,075	12,740
		B	2.3	39.9	49.3	8.5	3.99	....	....	....	....	7,355	13,240
		C	....	40.8	50.5	8.7	4.09	....	....	....	....	7,530	13,560
		D	....	44.7	55.3	....	4.48	....	....	....	....	8,255	14,860
20780	2.6	A	4.2	38.2	47.8	9.82	5.17	5.35	69.67	1.60	8.39	7,175	12,910
		B	1.7	39.2	49.0	10.08	5.31	5.20	71.54	1.64	6.23	7,365	13,260
		C	....	39.9	49.9	10.25	5.40	5.10	72.75	1.67	4.83	7,490	13,480
		D	....	44.5	55.5	....	6.02	5.68	81.06	1.86	5.38	8,345	15,020
20781	7.3	A	9.4	31.7	54.3	4.6	.81	....	....	....	....	7,150	12,870
		B	2.2	34.2	58.6	5.0	.87	....	....	....	....	7,715	13,890
		C	....	35.0	59.9	5.1	.89	....	....	....	....	7,895	14,210
		D	....	36.8	63.2	....	.94	....	....	....	....	8,315	14,970

OKLAHOMA—Continued.

TULSA COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20712	3.3	A	6.7	36.3	48.3	8.7	3.38					6,970	12,540
		B	3.5	37.6	49.9	9.0	3.50					7,210	12,980
		C		38.9	51.7	9.4	3.62					7,470	13,450
		D		42.9	57.1		3.99					8,240	14,840
20713	2.9	A	6.3	37.7	47.8	8.20	3.76	5.61	69.54	1.73	11.16	7,050	12,690
		B	3.4	38.9	49.3	8.45	3.87	5.44	71.65	1.78	8.81	7,265	13,080
		C		40.2	51.0	8.75	4.01	5.24	74.21	1.85	5.94	7,525	13,550
		D		44.1	55.9		4.39	5.74	81.33	2.03	6.51	8,245	14,850

WAGONER COUNTY.

20632	6.1	A	8.3	34.0	51.1	6.6	2.51					6,985	12,580
		B	2.3	36.2	54.4	7.1	2.68					7,440	13,390
		C		37.1	55.7	7.2	2.74					7,615	13,710
		D		40.0	60.0		2.95					8,210	14,780

OREGON.

COOS COUNTY.

19877	3.8	A	7.8	30.4	31.5	30.3	1.11					4,690	8,440
		B	4.2	31.6	32.7	31.5	1.15					4,875	8,770
		C		33.0	34.1	32.9	1.20					5,090	9,160
		D		49.1	50.9		1.79					7,585	13,650
19878	10.8	A	14.6	29.0	29.4	27.0	.56					4,410	7,930
		B	4.2	32.5	33.0	30.3	.63					4,940	8,890
		C		33.9	34.5	31.6	.66					5,160	9,290
		D		49.6	50.4		.97					7,550	13,590

PENNSYLVANIA.

SOMERSET COUNTY.

19848	3.3	A	4.0	17.8	71.8	6.4	0.87					7,810	14,060
		B	.7	18.4	74.2	6.7	.90					8,075	14,540
		C		18.5	74.8	6.7	.91					8,140	14,650
		D		19.9	80.1		.98					8,720	15,700
19849	2.1	A	2.7	17.2	73.5	6.6	.79					7,885	14,200
		B	.7	17.5	75.0	6.8	.81					8,050	14,490
		C		17.7	75.5	6.8	.81					8,110	14,600
		D		19.0	81.0		.87					8,700	15,660
19850	2.7	A	3.4	17.2	73.0	6.45	.83	4.75	81.53	1.43	5.01	7,835	14,100
		B	.8	17.6	75.0	6.63	.85	4.57	83.78	1.47	2.70	8,050	14,490
		C		17.7	75.6	6.68	.86	4.52	84.39	1.48	2.07	8,110	14,600
		D		19.0	81.0		.92	4.84	90.42	1.50	2.23	8,690	15,640
19851	2.0	A	2.9	20.9	65.9	10.29	1.39	4.47	76.78	1.08	5.99	7,405	13,330
		B	.9	21.4	67.2	10.50	1.42	4.33	78.37	1.10	4.28	7,560	13,600
		C		21.5	67.9	10.60	1.43	4.27	79.11	1.11	3.48	7,630	13,730
		D		24.1	75.9		1.60	4.78	88.49	1.24	3.89	8,535	15,360

TENNESSEE.

ANDERSON COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21427	0.8	A	2.1	40.5	53.4	4.0	1.60					7,900	14,220
		B	1.3	40.8	53.8	4.1	1.61					7,960	14,330
		C		41.3	54.6	4.1	1.63					8,070	14,530
		D		43.1	56.9		1.70					8,415	15,150
21451	1.1	A	2.4	37.2	56.7	3.7	2.03					7,970	14.350
		B	1.3	37.6	57.3	3.8	2.05					8,065	14,510
		C		38.1	58.1	3.8	2.08					8,170	14,710
		D		39.7	60.3		2.16					8,495	15,290
21452	.4	A	1.7	38.9	56.0	3.4	1.22					8,065	14,520
		B	1.3	39.1	56.2	3.4	1.22					8,095	14,570
		C		39.6	57.0	3.4	1.24					8,205	14,770
		D		41.0	59.0		1.28					8,500	15,300
21453	.6	A	1.9	39.1	54.3	4.7	1.75					7,955	14,320
		B	1.3	39.3	54.7	4.7	1.76					8,005	14,410
		C		39.8	55.4	4.8	1.78					8,110	14,590
		D		41.8	58.2		1.87					8,515	15,330
21455	.7	A	2.0	38.4	55.6	3.96	1.81	5.58	79.45	2.13	7.07	7,990	14,380
		B	1.3	38.6	56.1	3.99	1.82	5.54	80.02	2.15	6.48	8,045	14,480
		C		39.2	56.8	4.04	1.85	5.47	81.09	2.17	5.38	8,155	14,680
		D		40.8	59.2		1.93	5.70	84.50	2.26	5.61	8,495	15,290
21454	.4	A	1.3	41.7	51.1	5.9	1.60					8,010	14,420
		B	.9	41.9	51.3	5.9	1.61					8,045	14,480
		C		42.2	51.8	6.0	1.62					8,115	14,610
		D		44.9	55.1		1.72					8,635	15,550
21627	2.2	A	3.9	38.4	54.8	2.9	.84					7,855	14,140
		B	1.8	39.3	56.0	2.9	.86					8,035	14,460
		C		40.0	57.0	3.0	.87					8,175	14,720
		D		41.2	58.8		.90					8,430	15,170
21628	1.1	A	2.5	36.3	56.8	4.4	1.05					7,865	14,160
		B	1.5	36.7	57.4	4.4	1.06					7,950	14,310
		C		37.2	58.3	4.5	1.08					8,070	14,530
		D		39.0	61.0		1.13					8,450	15,210
21629	.8	A	2.0	37.9	53.1	7.0	1.76					7,675	13,820
		B	1.2	38.2	53.5	7.1	1.77					7,735	13,930
		C		38.7	54.1	7.2	1.80					7,830	14,090
		D		41.7	58.3		1.94					8,440	15,190
21630	1.0	A	2.2	37.4	53.7	6.7	1.89					7.715	13,880
		B	1.2	37.8	54.2	6.8	1.91					7,790	14,030
		C		38.2	54.9	6.9	1.93					7,885	14,190
		D		41.1	58.9		2.07					8,465	15,240
21631	1.0	A	2.2	37.2	54.5	6.12	1.59	5.40	77.61	1.83	7.45	7.755	13,960
		B	1.2	37.6	55.0	6.18	1.61	5.34	78.35	1.85	6.67	7,830	14,090
		C		38.0	55.7	6.26	1.63	5.28	79.35	1.87	5.61	7,930	14,270
		D		40.6	59.4		1.74	5.63	84.65	1.99	5.99	8,460	15,230
21636	.3	A	1.7	37.0	56.6	4.7	1.18					7,865	14,150
		B	1.4	37.1	56.8	4.7	1.18					7,890	14,200
		C		37.6	57.6	4.8	1.20					8,005	14.410
		D		39.5	60.5		1.26					8,405	15,130
21637	.5	A	2.0	36.1	56.3	5.6	.99					7,770	13,990
		B	1.5	36.3	56.6	5.6	1.00					7,810	14,060
		C		36.8	57.4	5.8	1.01					7,925	14,270
		D		39.1	60.9		1.07					8,410	15,140
21638	.6	A	1.7	36.3	55.0	7.0	.89					7,700	13,860
		B	1.1	36.5	55.3	7.1	.90					7,745	13,940
		C		36.9	55.9	7.2	.91					7,835	14,100
		D		39.8	60.2		.98					8,440	15,190
21639	.6	A	1.8	36.5	55.4	6.34	.99	5.47	78.06	1.92	7.22	7,730	13,920
		B	1.2	36.7	55.7	6.38	1.00	5.44	78.49	1.93	6.76	7,775	14,000
		C		37.2	56.4	6.45	1.01	5.38	79.46	1.95	5.75	7,870	14,170
		D		39.7	60.3		1.08	5.75	84.93	2.08	6.16	8,410	15,140

TENNESSEE—Continued.

ANDERSON COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21632	1.1	A	2.7	36.4	55.5	5.4	1.52	......	......	......	......	7,730	13,920
		B	1.5	36.8	56.2	5.5	1.54	......	......	......	......	7,820	14,070
		C	......	37.4	57.0	5.6	1.56	......	......	......	......	7,945	14,300
		D	......	39.6	60.4	......	1.65	......	......	......	......	8,410	15,140
21633	1.2	A	2.5	35.4	52.5	9.6	1.73	......	......	......	......	7,385	13,300
		B	1.4	35.8	53.1	9.7	1.75	......	......	......	......	7,475	13,460
		C	......	36.3	53.9	9.8	1.78	......	......	......	......	7,580	13,640
		D	......	40.3	59.7	......	1.97	......	......	......	......	8,400	15,120
21634	.6	A	2.0	35.9	51.8	10.3	1.65	......	......	......	......	7,345	13,230
		B	1.4	36.1	52.1	10.4	1.66	......	......	......	......	7,390	13,300
		C	......	36.6	52.8	10.6	1.68	......	......	......	......	7,495	13,490
		D	......	41.0	59.0	......	1.88	......	......	......	......	8,375	15,080
21635	1.0	A	2.4	36.0	53.2	8.39	1.61	5.27	75,23	1.80	7.70	7,510	13,520
		B	1.4	36.4	53.7	8.47	1.63	5.21	75.97	1.82	6.90	7,585	13,650
		C	......	36.9	54.5	8.59	1.65	5.13	77.03	1.84	5.76	7,690	13,840
		D	......	40.4	59.6	......	1.81	5.61	84.27	2.01	6.30	8,410	15,140
21680	.7	A	2.3	37.4	56.1	4.2	.89	......	......	......	......	7,880	14,180
		B	1.6	37.6	56.5	4.3	.90	......	......	......	......	7,935	14,280
		C	......	38.3	57.4	4.3	.91	......	......	......	......	8,065	14,520
		D	......	40.0	60.0	......	.95	......	......	......	......	8,430	15,170
21640	.7	A	2.2	36.0	56.4	5.4	.83	......	......	......	......	7,805	14,050
		B	1.5	36.2	56.8	5.5	.84	......	......	......	......	7,865	14,160
		C	......	36.8	57.6	5.6	.85	......	......	......	......	7,985	14,370
		D	......	39.0	61.0	......	.90	......	......	......	......	8,455	15,220
21641	.5	A	1.7	36.4	55.4	6.5	.91	......	......	......	......	7,765	13,980
		B	1.2	36.6	55.6	6.6	.91	......	......	......	......	7,805	14,050
		C	......	37.1	56.3	6.6	.93	......	......	......	......	7,900	14,220
		D	......	39.7	60.3	......	1.00	......	......	......	......	8,460	15,230
21642	.4	A	1.7	37.0	55.9	5.4	.82	......	......	......	......	7,875	14,170
		B	1.4	37.1	56.1	5.4	.82	......	......	......	......	7,905	14,230
		C	......	37.6	56.9	5.5	.83	......	......	......	......	8,015	14,420
		D	......	39.8	60.2	......	.88	......	......	......	......	8,480	15,260
21643	.7	A	2.0	37.0	55.5	5.5	.73	......	......	......	......	7,850	14,130
		B	1.3	37.3	55.9	5.5	.73	......	......	......	......	7,900	14,220
		C	......	37.7	56.7	5.6	.74	......	......	......	......	8,010	14,420
		D	......	40.0	60.0	......	.78	......	......	......	......	8,480	15,270
21644	.6	A	1.9	36.6	55.8	5.70	.87	5.49	78.75	1.88	7.31	7,830	14,090
		B	1.4	36.8	56.1	5.73	.87	5.46	79.20	1.89	6.85	7,875	14,170
		C	......	37.3	56.9	5.81	.89	5.38	80.30	1.92	5.70	7,980	14,370
		D	......	39.6	60.4	......	.94	5.71	85.25	2.04	6.06	8,475	15,250
21645	.6	A	1.9	36.5	56.0	5.6	1.49	......	......	......	......	7,850	14,130
		B	1.4	36.7	56.3	5.6	1.50	......	......	......	......	7,895	14,210
		C	......	37.2	57.1	5.7	1.52	......	......	......	......	8,005	14,410
		D	......	39.5	60.5	......	1.61	......	......	......	......	8,490	15,280
21646	.6	A	1.9	36.6	54.9	6.6	1.80	......	......	......	......	7,750	13,950
		B	1.3	36.8	55.2	6.7	1.81	......	......	......	......	7,795	14,030
		C	......	37.3	56.0	6.7	1.83	......	......	......	......	7,900	14,220
		D	......	40.0	60.0	......	1.96	......	......	......	......	8,470	15,250
21647	.5	A	1.8	37.3	56.9	4.0	.83	......	......	......	......	7,975	14,350
		B	1.4	37.4	57.2	4.0	.83	......	......	......	......	8,010	14,420
		C	......	37.9	58.0	4.1	.85	......	......	......	......	8,125	14,620
		D	......	39.6	60.4	......	.89	......	......	......	......	8,465	15,240
21648	.6	A	1.9	36.7	57.5	3.9	1.00	......	......	......	......	7,990	14,380
		B	1.3	36.9	57.8	4.0	1.01	......	......	......	......	8,035	14,470
		C	......	37.4	58.6	4.0	1.02	......	......	......	......	8,145	14,660
		D	......	38.9	61.1	......	1.06	......	......	......	......	8,485	15,280
21649	.6	A	1.8	36.6	56.5	5.08	1.32	5.42	78.95	1.91	7.32	7,890	14,200
		B	1.3	36.8	56.8	5.11	1.33	5.39	79.39	1.92	6.86	7,935	14,280
		C	......	37.3	57.5	5.17	1.34	5.32	80.42	1.95	5.80	8,035	14,470
		D	......	39.3	60.7	......	1.41	5.61	84.80	2.06	6.12	8,475	15,250

TENNESSEE—Continued.

BLEDSOE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22259	1.5	A	2.9	30.3	59.8	7.0	0.82					7,635	13,750
		B	1.4	30.8	60.7	7.1	.83					7,755	13,900
		C		31.2	61.6	7.2	.84					7,860	14,150
		D		33.6	66.4		.91					8,475	15,250
22260	1.7	A	3.1	28.7	58.8	9.4	1.25					7,430	13,380
		B	1.4	29.2	59.9	9.5	1.27					7,560	13,610
		C		29.6	60.7	9.7	1.29					7,665	13,800
		D		32.8	67.2		1.43					8,490	15,280
22261	1.6	A	3.1	29.8	58.9	8.24	1.02	5.09	76.67	1.43	7.55	7,530	13,560
		B	1.4	30.3	59.9	8.37	1.04	4.99	77.92	1.45	6.23	7,655	13,780
		C		30.7	60.8	8.50	1.05	4.90	79.05	1.47	5.03	7,765	13,980
		D		33.6	66.4		1.15	5.36	86.39	1.61	5.49	8,485	15,280

CAMPBELL COUNTY.

21650	0.6	A	2.1	36.4	58.1	3.4	0.86					7,985	14,380
		B	1.5	36.6	58.4	3.5	.87					8,035	14,460
		C		37.2	59.3	3.5	.88					8,160	14,680
		D		38.5	61.5		.91					8,455	15,220
21651	.7	A	2.2	36.7	56.5	4.6	.77					7,875	14,170
		B	1.5	37.0	56.8	4.7	.78					7,930	14,270
		C		37.5	57.7	4.8	.79					8,055	14,500
		D		39.4	60.6		.83					8,455	15,220
21652	.5	A	2.0	37.6	56.9	3.5	.81					7,985	14,370
		B	1.5	37.8	57.1	3.6	.81					8,025	14,450
		C		38.4	58.0	3.6	.83					8,145	14,660
		D		39.8	60.2		.86					8,450	15,210
21653	.6	A	2.1	36.6	57.5	3.83	.77	5.50	79.71	1.92	8.27	7,960	14,330
		B	1.5	36.8	57.8	3.85	.77	5.46	80.20	1.93	7.79	8,010	14,420
		C		37.4	58.7	3.91	.79	5.37	81.44	1.96	6.53	8,135	14,640
		D		38.9	61.1		.82	5.59	84.75	2.04	6.80	8,465	15,240
21654	1.1	A	3.3	38.1	50.8	7.8	1.00					7,345	13,220
		B	2.3	38.5	51.3	7.9	1.01					7,425	13,370
		C		39.4	52.5	8.1	1.03					7,600	13,680
		D		42.9	57.1		1.12					8,265	14,880
21655	1.5	A	3.8	38.3	52.8	5.1	1.37					7,535	13,560
		B	2.4	38.9	53.6	5.1	1.39					7,645	13,770
		C		39.8	54.9	5.3	1.42					7,830	14,100
		D		42.0	58.0		1.50					8,270	14,880
21656	1.1	A	3.5	39.3	51.4	5.8	1.05					7,475	13,460
		B	2.4	39.7	52.0	5.9	1.06					7,560	13,610
		C		40.7	53.3	6.0	1.09					7,745	13,940
		D		43.3	56.7		1.16					8,240	14,840
21657	1.1	A	3.4	38.6	52.7	5.3	1.12					7,485	13,480
		B	2.3	39.0	53.3	5.4	1.13					7,570	13,630
		C		39.9	54.6	5.5	1.16					7,750	13,950
		D		42.3	57.7		1.23					8,200	14,760
21658	1.2	A	3.5	38.6	51.9	6.03	1.13	5.55	75.95	1.70	9.64	7,450	13,410
		B	2.3	39.1	52.5	6.10	1.14	5.49	76.88	1.72	8.67	7,540	13,570
		C		40.0	53.8	6.25	1.17	5.35	78.66	1.76	6.81	7,715	13,890
		D		42.7	57.3		1.25	5.71	83.91	1.88	7.25	8,230	14,820
21677	1.4	A	4.0	37.3	55.3	3.4	.64					7,700	13,860
		B	2.7	37.8	56.1	3.4	.65					7,810	14,050
		C		38.8	57.7	3.5	.67					8,020	14,440
		D		40.2	59.8		.69					8,310	14,960
21678	1.0	A	3.5	38.4	54.4	3.7	.75					7,700	13,860
		B	2.5	38.8	54.9	3.8	.76					7,775	13,990
		C		39.8	56.3	3.9	.78					7,980	14,360
		D		41.4	58.6		.81					8,300	14,940

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21679	1.2	A	3.7	37.5	55.3	3.46	0.70	5.54	77.92	1.61	10.77	7,710	13,880
		B	2.5	38.0	56.0	3.50	.71	5.48	78.86	1.63	9.82	7,800	14,040
		C	....	38.9	57.5	3.59	.73	5.33	80.91	1.67	7.77	8,005	14,410
		D	....	40.4	59.6	....	.76	5.53	83.92	1.73	8.06	8,305	14,950
21659	1.2	A	3.6	38.4	53.7	4.3	1.01	....	....	....	....	7,610	13,690
		B	2.4	38.9	54.3	4.4	1.02	....	....	....	....	7,700	13,860
		C	....	39.8	55.7	4.5	1.05	....	....	....	....	7,895	14,210
		D	....	41.7	58.3	....	1.10	....	....	....	....	8,265	14,880
21660	1.3	A	3.4	37.7	51.7	7.2	1.34	....	....	....	....	7,355	13,240
		B	2.2	38.2	52.3	7.3	1.36	....	....	....	....	7,450	13,410
		C	....	39.0	53.6	7.4	1.39	....	....	....	....	7,620	13,710
		D	....	42.2	57.8	....	1.50	....	....	....	....	8,225	14,810
21661	1.1	A	3.5	38.8	52.7	5.0	1.30	....	....	....	....	7,600	13,680
		B	2.4	39.3	53.3	5.0	1.31	....	....	....	....	7,685	13,840
		C	....	40.2	54.6	5.2	1.35	....	....	....	....	7,875	14,180
		D	....	42.4	57.6	....	1.42	....	....	....	....	8,305	14,950
21662	1.2	A	3.3	38.8	50.9	7.0	1.14	....	....	....	....	7,385	13,290
		B	2.2	39.2	51.5	7.1	1.15	....	....	....	....	7,470	13,440
		C	....	40.1	52.6	7.3	1.18	....	....	....	....	7,640	13,750
		D	....	43.3	56.7	....	1.27	....	....	....	....	8,240	14,830
21663	1.2	A	3.4	38.4	52.4	5.82	1.22	5.53	75.36	1.77	10.30	7,500	13,500
		B	2.2	38.9	53.0	5.89	1.23	5.46	76.26	1.79	9.37	7,585	13,660
		C	....	39.8	54.2	6.02	1.26	5.32	78.00	1.83	7.57	7,760	13,970
		D	....	42.3	57.7	....	1.34	5.66	83.00	1.95	8.05	8,255	14,860
21664	2.2	A	4.7	37.5	54.0	3.8	.69	....	....	....	....	7,555	13,600
		B	2.6	38.3	55.2	3.9	.71	....	....	....	....	7,720	13,900
		C	....	39.3	56.7	4.0	.72	....	....	....	....	7,930	14,270
		D	....	41.0	59.0	....	.75	....	....	....	....	8,255	14,860
21668	1.3	A	3.5	39.3	52.2	5.0	1.18	....	....	....	....	7,565	13,620
		B	2.2	39.9	52.8	5.1	1.20	....	....	....	....	7,665	13,800
		C	....	40.8	54.0	5.2	1.22	....	....	....	....	7,840	14,120
		D	....	43.0	57.0	....	1.29	....	....	....	....	8,270	14,880
21669	1.2	A	3.4	37.8	50.6	8.2	1.00	....	....	....	....	7,290	13,120
		B	2.2	38.3	51.2	8.3	1.01	....	....	....	....	7,375	13,280
		C	....	39.2	52.3	8.5	1.03	....	....	....	....	7,545	13,580
		D	....	42.8	57.2	....	1.13	....	....	....	....	8,245	14,850
21670	1.4	A	3.7	38.1	53.3	4.9	.87	....	....	....	....	7,570	13,630
		B	2.3	38.6	54.1	5.0	.88	....	....	....	....	7,675	13,820
		C	....	39.5	55.4	5.1	.90	....	....	....	....	7,860	14,150
		D	....	41.6	58.4	....	.95	....	....	....	....	8,280	14,900
21671	.9	A	3.2	39.2	51.9	5.7	1.10	....	....	....	....	7,525	13,550
		B	2.3	39.6	52.4	5.7	1.11	....	....	....	....	7,595	13,680
		C	....	40.5	53.6	5.9	1.14	....	....	....	....	7,775	14,000
		D	....	43.1	56.9	....	1.21	....	....	....	....	8,260	14,860
21672	1.2	A	3.5	38.5	52.2	5.84	1.00	5.57	75.01	1.74	10.84	7,485	13,480
		B	2.3	38.9	52.9	5.91	1.01	5.51	75.93	1.76	9.88	7,580	13,640
		C	....	39.9	54.1	6.05	1.04	5.38	77.70	1.80	8.03	7,755	13,960
		D	....	42.4	57.6	....	1.11	5.73	82.71	1.92	8.53	8.255	14,860
21665	.6	A	2.1	37.1	56.4	4.4	1.47	....	....	....	....	7,825	14,080
		B	1.6	37.3	56.7	4.4	1.48	....	....	....	....	7,865	14,160
		C	....	37.9	57.6	4.5	1.50	....	....	....	....	7,990	14,380
		D	....	39.7	60.3	....	1.57	....	....	....	....	8,365	15,060
21666	.3	A	1.7	38.2	56.2	3.9	.85	....	....	....	....	7,900	14,220
		B	1.4	38.3	56.4	3.9	.85	....	....	....	....	7,925	14,270
		C	....	38.8	57.2	4.0	.87	....	....	....	....	8,040	14,470
		D	....	40.4	59.6	....	.91	....	....	....	....	8,375	15,080
21667	.4	A	1.9	37.7	56.3	4.09	1.23	5.49	79.27	1.94	7.98	7,875	14,180
		B	1.5	37.8	56.6	4.11	1.24	5.46	79.61	1.95	7.63	7,910	14,240
		C	....	38.4	57.4	4.17	1.25	5.37	80.85	1.98	6.38	8,035	14,460
		D	....	40.1	59.9	....	1.30	5.60	84.37	2.07	6.66	8,385	15,090

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21673	0.6	A	2.1	37.2	56.5	4.2	0.82	....	....	....	....	7,900	14,220
		B	1.6	37.4	56.8	4.2	.83	....	....	....	....	7,950	14,310
		C	....	38.0	57.7	4.3	.84	....	....	....	....	8,075	14,530
		D	....	39.7	60.3	....	.88	....	....	....	....	8,435	15,190
21674	.7	A	2.3	36.7	56.8	4.2	1.06	....	....	....	....	7,870	14,170
		B	1.6	36.9	57.2	4.3	1.07	....	....	....	....	7,925	14,270
		C	....	37.5	58.2	4.3	1.08	....	....	....	....	8,055	14,500
		D	....	39.2	60.8	....	1.13	....	....	....	....	8,420	15,160
21675	.7	A	2.3	36.7	56.5	4.5	.87	....	....	....	....	7,870	14,160
		B	1.6	37.0	56.9	4.5	.88	....	....	....	....	7,925	14,260
		C	....	37.6	57.9	4.5	.89	....	....	....	....	8,055	14,500
		D	....	39.4	60.6	....	.93	....	....	....	....	8,440	15,190
21676	.7	A	2.3	36.7	56.8	4.16	.92	5.51	79.20	1.87	8.34	7,885	14,190
		B	1.6	36.9	57.3	4.19	.93	5.48	79.73	1.88	7.79	7,935	14,290
		C	....	37.5	58.2	4.26	.94	5.40	81.05	1.91	6.44	8,070	14,520
		D	....	39.2	60.8	....	.98	5.64	84.65	1.99	6.74	8,425	15,170
21687	1.8	A	4.4	36.7	54.8	4.1	1.35	....	....	....	....	7,490	13,480
		B	2.7	37.4	55.8	4.1	1.37	....	....	....	....	7,625	13,730
		C	....	38.4	57.4	4.2	1.41	....	....	....	....	7,835	14,110
		D	....	40.1	59.9	....	1.47	....	....	....	....	8,185	14,730
21688	1.8	A	4.2	37.5	55.5	2.8	.98	....	....	....	....	7,635	13,740
		B	2.5	38.2	56.5	2.8	1.00	....	....	....	....	7,775	13,990
		C	....	39.2	57.9	2.9	1.02	....	....	....	....	7,970	14,350
		D	....	40.3	59.7	....	1.05	....	....	....	....	8,210	14,780
21689	1.8	A	4.3	37.1	55.1	3.52	1.19	5.62	76.72	1.84	11.11	7,585	13,660
		B	2.5	37.8	56.1	3.59	1.21	5.53	78.14	1.87	9.66	7,730	13,910
		C	....	38.8	57.5	3.68	1.24	5.37	80.16	1.92	7.63	7,925	14,270
		D	....	40.3	59.7	....	1.29	5.58	83.22	1.99	7.92	8,230	14,810
21690	1.7	A	3.9	38.9	55.2	2.0	.79	....	....	....	....	7,775	14,000
		B	2.3	39.6	56.1	2.0	.80	....	....	....	....	7,910	14,240
		C	....	40.5	57.5	2.0	.82	....	....	....	....	8,095	14,580
		D	....	41.3	58.7	....	.84	....	....	....	....	8,265	14,880
21691	1.7	A	3.8	39.2	54.7	2.3	.89	....	....	....	....	7,770	13,980
		B	2.1	39.9	55.7	2.3	.91	....	....	....	....	7,905	14,230
		C	....	40.8	56.9	2.3	.93	....	....	....	....	8,075	14,540
		D	....	41.7	58.3	....	.95	....	....	....	....	8,270	14,890
21692	1.6	A	3.9	38.8	55.5	1.8	.80	....	....	....	....	7,795	14,030
		B	2.3	39.4	56.4	1.9	.81	....	....	....	....	7,920	14,250
		C	....	40.3	57.8	1.9	.83	....	....	....	....	8,105	14,590
		D	....	41.1	58.9	....	.85	....	....	....	....	8,265	14,870
21693	1.7	A	3.9	38.8	55.2	2.07	.86	5.75	78.49	1.95	10.88	7,880	14,000
		B	2.3	39.5	56.1	2.11	.87	5.66	79.82	1.98	9.56	7,910	14,240
		C	....	40.4	57.4	2.16	.90	5.53	81.72	2.03	7.66	8,100	14,580
		D	....	41.3	58.7	....	.92	5.65	83.53	2.07	7.83	8,280	14,900
21694	1.8	A	4.2	36.3	56.5	3.0	.64	....	....	....	....	7,625	13,720
		B	2.5	36.9	57.6	3.0	.65	....	....	....	....	7,760	13,970
		C	....	37.9	59.0	3.1	.67	....	....	....	....	7,960	14,330
		D	....	39.1	60.9	....	.69	....	....	....	....	8,215	14,790
21695	2.0	A	4.4	36.0	56.6	3.0	.69	....	....	....	....	7,575	13,640
		B	2.4	36.7	57.8	3.1	.70	....	....	....	....	7,730	13,910
		C	....	37.6	59.3	3.1	.72	....	....	....	....	7,925	14,260
		D	....	38.8	61.2	....	.74	....	....	....	....	8,180	14,730
21696	1.6	A	4.0	37.5	55.7	2.8	.76	....	....	....	....	7,640	13,750
		B	2.5	38.2	56.5	2.8	.77	....	....	....	....	7,760	13,970
		C	....	39.1	58.0	2.9	.79	....	....	....	....	7,960	14,330
		D	....	40.3	59.7	....	.81	....	....	....	....	8,200	14,760
21697	2.0	A	4.6	36.3	55.6	3.5	.74	....	....	....	....	7,540	13,570
		B	2.6	37.0	56.8	3.6	.76	....	....	....	....	7,695	13,860
		C	....	38.0	58.3	3.7	.78	....	....	....	....	7,905	14,230
		D	....	39.5	60.5	....	.81	....	....	....	....	8,205	14,770

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21698	1.9	A	4.3	36.7	55.9	3.09	0.71	5.58	77.38	1.93	11.31	7,595	13,670
		B	2.5	37.4	56.9	3.15	.72	5.47	78.84	1.97	9.85	7,740	13,930
		C	....	38.4	58.4	3.23	.74	5.33	80.88	2.02	7.80	7,940	14,290
		D	....	39.6	60.4	....	.76	5.51	83.58	2.09	8.06	8,205	14,770
21699	1.3	A	3.2	37.5	56.3	3.0	1.13	....	....	....	....	7,790	14,020
		B	1.9	38.0	57.1	3.0	1.14	....	....	....	....	7,890	14,200
		C	....	38.8	58.1	3.1	1.17	....	....	....	....	8,045	14,480
		D	....	40.0	60.0	....	1.21	....	....	....	....	8,300	14,940
21700	1.0	A	3.0	37.8	55.8	3.4	.78	....	....	....	....	7,820	14,080
		B	2.0	38.2	56.4	3.4	.79	....	....	....	....	7,905	14,230
		C	....	39.0	57.5	3.5	.80	....	....	....	....	8,060	14,510
		D	....	40.4	59.6	....	.83	....	....	....	....	8,355	15,040
21701	1.1	A	3.3	37.1	55.9	3.7	1.49	....	....	....	....	7,685	13,830
		B	2.3	37.5	56.5	3.7	1.51	....	....	....	....	7,770	13,980
		C	....	38.4	57.8	3.8	1.54	....	....	....	....	7,950	14,310
		D	....	39.9	60.1	....	1.60	....	....	....	....	8,260	14,870
21702	1.1	A	3.2	37.5	56.6	2.7	.89	....	....	....	....	7,835	14,100
		B	2.2	37.9	57.2	2.7	.90	....	....	....	....	7,920	14,250
		C	....	38.8	58.5	2.7	.92	....	....	....	....	8,095	14,570
		D	....	39.9	60.1	....	.95	....	....	....	....	8,325	14,990
21703	1.1	A	3.1	37.4	56.3	3.23	1.04	5.62	78.56	1.96	9.59	7,785	14,010
		B	2.0	37.8	56.9	3.27	1.05	5.56	79.44	1.98	8.70	7,870	14,170
		C	....	38.6	58.1	3.33	1.07	5.44	81.09	2.02	7.05	8,035	14,470
		D	....	39.9	60.1	....	1.11	5.63	83.88	2.09	7.29	8,310	14,960
21802	2.2	A	4.4	38.0	55.1	2.5	.69	....	....	....	....	7,720	13,900
		B	2.2	38.8	56.4	2.6	.71	....	....	....	....	7,895	14,210
		C	....	39.7	57.7	2.6	.72	....	....	....	....	8,075	14,540
		D	....	40.8	59.2	....	.74	....	....	....	....	8,295	14,930
21803	1.6	A	3.7	39.0	54.8	2.5	.68	....	....	....	....	7,755	13,960
		B	2.2	39.6	55.7	2.5	.69	....	....	....	....	7,880	14,180
		C	....	40.5	56.9	2.6	.71	....	....	....	....	8,055	14,500
		D	....	41.6	58.4	....	.74	....	....	....	....	8,270	14,890
21804	2.1	A	4.2	38.7	55.5	1.6	.68	....	....	....	....	7,820	14,080
		B	2.2	39.5	56.7	1.6	.69	....	....	....	....	7,990	14,380
		C	....	40.4	58.0	1.6	.71	....	....	....	....	8,165	14,700
		D	....	41.1	58.9	....	.72	....	....	....	....	8,305	14,950
21805	2.0	A	4.1	38.6	55.1	2.22	.72	5.87	77.87	2.01	11.31	7,765	13,980
		B	2.1	39.3	56.3	2.26	.73	5.76	79.44	2.05	9.76	7,920	14,260
		C	....	40.2	57.5	2.31	.75	5.65	81.16	2.10	8.03	8,095	14,570
		D	....	41.2	58.8	....	.77	5.78	83.08	2.15	8.22	8,285	14,920
21806	1.6	A	3.7	37.9	53.8	4.6	2.23	....	....	....	....	7,595	13,670
		B	2.1	38.5	54.7	4.7	2.27	....	....	....	....	7,720	13,890
		C	....	39.3	55.9	4.8	2.32	....	....	....	....	7,885	14,200
		D	....	41.3	58.7	....	2.44	....	....	....	....	8,280	14,910
21807	1.6	A	3.6	38.8	53.9	3.7	1.50	....	....	....	....	7,650	13,770
		B	2.0	39.4	54.8	3.8	1.52	....	....	....	....	7,770	13,990
		C	....	40.2	55.9	3.9	1.56	....	....	....	....	7,930	14,280
		D	....	41.9	58.1	....	1.62	....	....	....	....	8,250	14,850
21808	1.2	A	3.4	39.2	53.2	4.2	1.72	....	....	....	....	7,655	13,780
		B	2.2	39.7	53.8	4.3	1.74	....	....	....	....	7,745	13,940
		C	....	40.6	55.0	4.4	1.78	....	....	....	....	7,920	14,260
		D	....	42.5	57.5	....	1.86	....	....	....	....	8,285	14,910
21809	1.5	A	3.8	37.9	53.7	4.6	2.12	....	....	....	....	7,565	13,620
		B	2.3	38.5	54.5	4.7	2.15	....	....	....	....	7,685	13,830
		C	....	39.4	55.8	4.8	2.20	....	....	....	....	7,865	14,160
		D	....	41.4	58.6	....	2.31	....	....	....	....	8,260	14,870
21810	1.5	A	3.6	38.7	53.4	4.29	1.88	5.78	76.49	1.96	9.60	7,625	13,730
		B	2.2	39.3	54.2	4.35	1.91	5.70	77.62	1.99	8.43	7,740	13,930
		C	....	40.2	55.4	4.45	1.95	5.58	79.37	2.03	6.62	7,915	14,250
		D	....	42.0	58.0	....	2.04	5.84	83.07	2.12	6.93	8,285	14,910

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21811	1.8	A	4.3	39.0	53.8	2.9	1.41					7,685	13,840
		B	2.6	39.6	54.8	3.0	1.44					7,825	14,090
		C		40.7	56.2	3.1	1.47					8,030	14,460
		D		42.0	58.0		1.52					8,285	14,910
21812	1.8	A	4.6	37.9	56.3	1.2	.75					7,795	14,030
		B	2.8	38.6	57.3	1.3	.76					7,935	14,280
		C		39.7	59.0	1.3	.79					8,165	14,700
		D		40.2	59.8		.80					8,275	14,890
21813	1.7	A	4.4	38.4	55.7	1.5	.86					7,800	14,040
		B	2.8	39.1	56.6	1.5	.87					7,930	14,280
		C		40.2	58.3	1.5	.90					8,165	14,690
		D		40.8	59.2		.91					8,290	14,920
21814	1.7	A	4.4	38.4	55.3	1.86	1.04	5.94	78.89	1.99	10.28	7,745	13,940
		B	2.7	39.1	56.3	1.89	1.06	5.85	80.20	2.03	8.89	7,880	14,190
		C		40.2	57.9	1.95	1.09	5.70	82.55	2.08	6.63	8,105	14,590
		D		40.9	59.1		1.11	5.81	84.19	2.12	6.77	8,265	14,880
21821	2.8	A	4.9	39.1	51.9	4.1	2.22					7,520	13,530
		B	2.1	40.3	53.4	4.2	2.28					7,735	13,930
		C		41.2	54.5	4.3	2.33					7,905	14,230
		D		43.0	57.0		2.44					8,265	14,880
21822	1.8	A	4.0	39.6	51.2	5.2	1.45					7,530	13,560
		B	2.1	40.4	52.2	5.3	1.48					7,670	13,810
		C		41.3	53.3	5.4	1.51					7,840	14.110
		D		43.6	56.4		1.60					8,285	14,920
21823	1.9	A	4.1	39.3	52.2	4.4	1.76					7,595	13,670
		B	2.2	40.1	53.2	4.5	1.79					7,740	13,930
		C		41.0	54.4	4.6	1.83					7,915	14,250
		D		43.0	57.0		1.92					8,290	14,920
21824	2.2	A	4.2	39.7	51.5	4.58	1.79	5.79	74.74	1.94	11.16	7,555	13,600
		B	2.1	40.6	52.6	4.68	1.83	5.67	76.41	1.98	9.43	7,725	13,900
		C		41.4	53.8	4.78	1.87	5.56	78.07	2.03	7.69	7,890	14,200
		D		43.5	56.5		1.96	5.84	81.99	2.13	8.08	8,285	14,920
21825	2.1	A	4.1	37.1	55.0	3.8	1.25					7,640	13,750
		B	2.1	37.8	56.2	3.9	1.28					7,800	14,040
		C		38.6	57.4	4.0	1.30					7,965	14,340
		D		40.2	59.8		1.35					8,300	14,940
21826	2.0	A	3.9	36.0	53.5	6.6	1.44					7,405	13,330
		B	1.9	36.8	54.6	6.7	1.47					7,555	13,600
		C		37.5	55.7	6.8	1.50					7,705	13,870
		D		40.3	59.7		1.61					8,270	14,890
21827	1.5	A	3.4	38.1	54.1	4.4	1.81					7,675	13,820
		B	1.9	38.7	54.9	4.5	1.84					7,790	14,020
		C		39.5	56.0	4.5	1.87					7,945	14,300
		D		41.4	58.6		1.96					8,320	14,970
21828	2.5	A	4.3	37.3	52.8	5.6	2.50					7,500	13,500
		B	1.8	38.3	54.2	5.7	2.56					7,695	13,850
		C		39.0	55.2	5.8	2.61					7,835	14,100
		D		41.4	58.6		2.77					8,320	14,970
21829	1.4	A	3.3	38.3	53.7	4.7	1.16					7,655	13,780
		B	1.9	38.8	54.5	4.8	1.18					7,765	13,980
		C		39.6	55.6	4.8	1.20					7,920	14,250
		D		41.6	58.4		1.26					8,320	14,980
21830	1.8	A	3.6	37.9	53.6	4.85	1.82	5.65	76.08	1.90	9.70	7,595	13,670
		B	1.8	38.7	54.6	4.94	1.85	5.55	77.48	1.93	8.25	7,735	13,930
		C		39.4	55.6	5.03	1.89	5.45	78.92	1.97	6.74	7,880	14,180
		D		41.4	58.6		1.99	5.74	83.10	2.07	7.10	8,295	14,940
21831	2.2	A	4.5	36.0	57.0	2.5	1.08					7,640	13,750
		B	2.4	36.8	58.3	2.5	1.10					7,810	14,060
		C		37.7	59.7	2.6	1.13					8,000	14,400
		D		38.7	61.3		1.16					8,215	14,790

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21832	2.0	A	4.5	37.7	55.7	2.1	0.75					7,740	13,930
		B	2.6	38.5	56.8	2.1	.77					7,890	14,210
		C		39.5	58.3	2.2	.79					8,100	14,580
		D		40.4	59.6		.81					8,280	14,900
21833	2.3	A	4.8	36.6	55.3	3.3	1.41					7,585	13,650
		B	2.6	37.5	56.5	3.4	1.44					7,760	13,970
		C		38.5	58.0	3.5	1.48					7,965	14,340
		D		39.9	60.1		1.53					8,250	14,850
21834	2.4	A	4.8	38.1	53.0	4.1	2.01					7,495	13,500
		B	2.4	39.1	54.3	4.2	2.06					7,685	13,830
		C		40.0	55.7	4.3	2.11					7,870	14,170
		D		41.8	58.2		2.20					8,225	14,810
21835	2.2	A	4.7	36.8	55.3	3.16	1.36	5.78	76.39	2.00	11.31	7,600	13,680
		B	2.5	37.7	56.6	3.23	1.39	5.65	78.12	2.05	9.56	7,770	14,000
		C		38.6	58.1	3.32	1.43	5.52	80.15	2.10	7.48	7,975	14,350
		D		40.0	60.0		1.48	5.71	82.90	2.17	7.74	8,245	14,840
21836	2.0	A	4.4	39.6	53.7	2.3	1.00					7,640	13,750
		B	2.4	40.5	54.8	2.3	1.02					7,795	14,040
		C		41.5	56.2	2.3	1.05					7,990	14,380
		D		42.5	57.5		1.08					8,185	14,730
21837	2.2	A	4.5	38.4	55.3	1.8	.86					7,665	13,790
		B	2.4	39.3	56.5	1.8	.88					7,835	14,100
		C		40.2	57.9	1.9	.90					8,020	14,440
		D		41.0	59.0		.92					8,175	14,720
21838	2.1	A	4.6	38.9	54.5	2.05	.95	5.96	77.04	1.96	12.04	7,665	13,800
		B	2.5	39.8	55.6	2.09	.97	5.85	78.68	2.00	10.41	7,830	14,090
		C		40.8	57.1	2.15	1.00	5.71	80.72	2.05	8.37	8,030	14,450
		D		41.7	58.3		1.02	5.84	82.50	2.09	8.55	8,205	14,770
21839	2.1	A	4.3	38.2	55.5	2.0	.97					7,735	13,930
		B	2.2	39.0	56.8	2.0	.99					7,900	14,220
		C		39.9	58.0	2.1	1.01					8,080	14,550
		D		40.7	59.3		1.03					8,255	14,860
21840	1.8	A	3.8	38.4	55.7	2.1	.92					7,765	13,970
		B	2.0	39.2	56.7	2.1	.94					7,910	14,230
		C		40.0	57.9	2.1	.96					8,075	14,530
		D		40.8	59.2		.98					8,250	14,850
21841	1.9	A	3.7	38.6	54.4	3.3	1.27					7,660	13,790
		B	1.8	39.3	55.5	3.4	1.29					7,810	14,050
		C		40.0	56.5	3.5	1.32					7,955	14,320
		D		41.5	58.5		1.37					8,240	14,800
21842	2.0	A	3.8	37.8	54.9	3.5	1.16					7,640	13,750
		B	1.8	38.6	56.0	3.6	1.18					7,795	14,030
		C		39.3	57.0	3.7	1.20					7,940	14,290
		D		40.8	59.2		1.25					8,245	14,840
21843	1.9	A	3.9	38.0	55.2	2.92	1.09	5.76	77.23	1.97	11.03	7,685	13,840
		B	2.0	38.8	56.2	2.98	1.11	5.66	78.72	2.01	9.52	7,835	14,100
		C		39.6	57.4	3.04	1.13	5.54	80.34	2.05	7.90	7,995	14,390
		D		40.8	59.2		1.17	5.71	82.86	2.11	8.15	8,245	14,850
21853	1.7	A	3.5	36.8	56.6	3.1	.79					7,825	14,090
		B	1.8	37.4	57.6	3.2	.80					7,960	14,330
		C		38.1	58.6	3.3	.82					8,110	14,600
		D		39.4	60.6		.85					8,385	15,090
21854	1.0	A	2.9	36.8	57.1	3.2	.82					7,870	14,160
		B	1.9	37.2	57.7	3.2	.83					7,945	14,300
		C		37.9	58.8	3.3	.84					8,100	14,580
		D		39.2	60.8		.87					8,375	15,070
21855	1.3	A	3.3	36.7	57.2	2.8	.86					7,840	14,110
		B	2.0	37.2	57.9	2.9	.87					7,945	14,300
		C		38.0	59.1	2.9	.89					8,105	14,590
		D		39.1	60.9		.92					8,345	15,020

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21856	1.3	A	3.2	36.8	56.9	3.11	0.87	5.59	78.83	1.99	9.61	7,845	14,120
		B	1.9	37.3	57.6	3.15	.88	5.52	79.88	2.02	8.55	7,950	14,310
		C	....	38.1	58.7	3.21	.90	5.40	81.46	2.06	6.97	8,110	14,590
		D	....	39.3	60.7	....	.93	5.58	84.16	2.13	7.20	8,375	15,080
21871	1.5	A	4.4	37.7	55.8	2.1	.81	....	....	....	....	7,665	13,800
		B	2.9	38.3	56.7	2.1	.82	....	....	....	....	7,790	14,020
		C	....	39.4	58.4	2.2	.85	....	....	....	....	8,020	14,440
		D	....	40.3	59.7	....	.87	....	....	....	....	8,195	14,760
21872	1.4	A	4.3	38.7	55.3	1.7	.88	....	....	....	....	7,710	13,870
		B	2.9	39.2	56.1	1.8	.89	....	....	....	....	7,820	14,080
		C	....	40.4	57.8	1.8	.92	....	....	....	....	8,055	14,500
		D	....	41.2	58.8	....	.94	....	....	....	....	8,200	14,760
21873	1.5	A	4.4	38.0	55.7	1.92	.85	5.79	77.67	2.12	11.65	7,710	13,880
		B	2.9	38.5	56.6	1.95	.86	5.71	78.84	2.15	10.49	7,830	14,090
		C	....	39.7	58.3	2.01	.89	5.54	81.24	2.22	8.10	8,065	14,520
		D	....	40.5	59.5	....	.91	5.65	82.91	2.27	8.26	8,230	14,820
21924	2.0	A	4.9	39.6	53.7	1.8	1.06	....	....	....	....	7,615	13,710
		B	2.9	40.4	54.8	1.9	1.08	....	....	....	....	7,770	13,990
		C	....	41.6	56.5	1.9	1.11	....	....	....	....	8,010	14,410
		D	....	42.4	57.6	....	1.13	....	....	....	....	8,165	14,690
21925	1.4	A	4.4	39.6	54.1	1.9	.95	....	....	....	....	7,645	13,770
		B	3.0	40.2	54.9	1.9	.96	....	....	....	....	7,755	13,960
		C	....	41.4	56.6	2.0	.99	....	....	....	....	8,000	14,400
		D	....	42.2	57.8	....	1.01	....	....	....	....	8,160	14,690
21926	1.3	A	4.2	39.8	53.6	2.4	.93	....	....	....	....	7,610	13,700
		B	2.9	40.3	54.3	2.5	.94	....	....	....	....	7,715	13,890
		C	....	41.5	55.9	2.6	.97	....	....	....	....	7,945	14,300
		D	....	42.6	57.4	....	1.00	....	....	....	....	8,150	14,670
21927	1.6	A	4.4	39.6	54.0	2.04	1.00	5.81	76.45	2.01	12.69	7,625	13,720
		B	2.8	40.2	54.9	2.07	1.02	5.72	77.69	2.04	11.46	7,745	13,940
		C	....	41.4	56.5	2.13	1.05	5.56	79.97	2.10	9.19	7,975	14,350
		D	....	42.3	57.7	....	1.07	5.68	81.71	2.15	9.39	8,150	14,670
21928	2.0	A	5.1	37.7	54.1	3.1	.85	....	....	....	....	7,430	13,370
		B	3.2	38.4	55.2	3.2	.87	....	....	....	....	7,580	13,640
		C	....	39.7	57.0	3.3	.90	....	....	....	....	7,830	14,090
		D	....	41.1	58.9	....	.93	....	....	....	....	8,095	14,570
21929	2.1	A	5.7	36.7	55.9	1.7	.96	....	....	....	....	7,505	13,510
		B	3.7	37.5	57.1	1.7	.98	....	....	....	....	7,665	13,790
		C	....	39.0	59.2	1.8	1.02	....	....	....	....	7,955	14,320
		D	....	39.7	60.3	....	1.04	....	....	....	....	8,100	14,580
21930	2.0	A	5.4	37.5	54.7	2.44	.89	5.76	75.22	1.99	13.75	7,465	13,440
		B	3.5	38.2	55.9	2.39	.91	5.65	76.77	2.03	12.20	7,620	13,720
		C	....	39.6	57.9	2.53	.94	5.45	79.52	2.10	9.46	7,895	14,210
		D	....	40.6	59.4	....	.96	5.59	81.59	2.15	9.71	8,100	14,580
21931	2.5	A	4.8	37.0	56.5	1.7	.87	....	....	....	....	7,705	13,870
		B	2.4	37.9	57.9	1.8	.89	....	....	....	....	7,900	14,220
		C	....	38.8	59.4	1.8	.91	....	....	....	....	8,095	14,570
		D	....	39.5	60.5	....	.93	....	....	....	....	8,245	14,850
21932	1.8	A	4.2	38.4	55.7	1.7	.77	....	....	....	....	7,740	13,930
		B	2.5	39.0	56.7	1.8	.78	....	....	....	....	7,880	14,180
		C	....	40.0	58.2	1.8	.80	....	....	....	....	8,080	14,540
		D	....	40.8	59.2	....	.81	....	....	....	....	8,225	14,810
21933	2.1	A	4.5	37.8	56.0	1.66	.79	5.81	78.47	2.06	11.21	7,725	13,900
		B	2.4	38.6	57.3	1.70	.81	5.69	80.17	2.10	9.53	7,890	14,200
		C	....	39.6	58.7	1.74	.83	5.56	82.18	2.16	7.53	8,090	14,560
		D	....	40.3	59.7	....	.84	5.66	83.63	2.20	7.67	8,230	14,820
21996	1.8	A	5.1	37.0	56.2	1.7	.81	....	....	....	....	7,640	13,760
		B	3.4	37.7	57.2	1.7	.82	....	....	....	....	7,780	14,000
		C	....	39.0	59.2	1.8	.85	....	....	....	....	8,055	14,500
		D	....	39.7	60.3	....	.87	....	....	....	....	8,200	14,760

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21997	0.5	A	1.5	45.1	34.1	19.3	1.16	......	......	......	......	6,855	12,340
		B	1.0	45.3	34.3	19.4	1.17	......	......	......	......	6,885	12,400
		C	......	45.7	34.7	19.6	1.18	......	......	......	......	6,960	12,530
		D	......	56.9	43.1	......	1.47	......	......	......	......	8,655	15,580
21998	1.3	A	4.6	39.2	53.9	2.3	1.20	......	......	......	......	7,590	13,660
		B	3.4	39.7	54.6	2.3	1.22	......	......	......	......	7,685	13,840
		C	......	41.1	56.5	2.4	1.26	......	......	......	......	7,955	14,320
		D	......	42.1	57.9	......	1.29	......	......	......	......	8,145	14,660
21999	1.9	A	5.2	37.8	54.6	2.4	.91	......	......	......	......	7,550	13,590
		B	3.4	38.5	55.7	2.4	.93	......	......	......	......	7,695	13,850
		C	......	39.9	57.6	2.5	.96	......	......	......	......	7,965	14,340
		D	......	40.9	59.1	......	.98	......	......	......	......	8,170	14,700
22000	1.7	A	4.6	38.5	53.0	3.9	1.11	......	......	......	......	7,485	13,480
		B	3.0	39.1	53.9	4.0	1.13	......	......	......	......	7,615	13,700
		C	......	40.3	55.5	4.2	1.16	......	......	......	......	7,850	14,130
		D	......	42.1	57.9	......	1.21	......	......	......	......	8,190	14,740
22001	2.3	A	5.5	38.0	54.4	2.1	.81	......	......	......	......	7,585	13,650
		B	3.3	38.9	55.6	2.2	.83	......	......	......	......	7,760	13,970
		C	......	40.2	57.5	2.3	.86	......	......	......	......	8,025	14,440
		D	......	41.1	58.9	......	.88	......	......	......	......	8,210	14,780
22002	1.7	A	5.1	38.7	54.6	1.6	.85	......	......	......	......	7,655	13,780
		B	3.4	39.4	55.6	1.6	.87	......	......	......	......	7,790	14,020
		C	......	40.8	57.5	1.7	.90	......	......	......	......	8,065	14,520
		D	......	41.5	58.5	......	.92	......	......	......	......	8,205	14,770
22003	2.0	A	5.2	38.1	54.8	1.92	.83	5.89	76.34	2.10	12.92	7,625	13,730
		B	3.2	38.9	55.9	1.96	.85	5.79	77.89	2.14	11.37	7,780	14,010
		C	......	40.2	57.8	2.03	.88	5.60	80.52	2.21	8.76	8,045	14,480
		D	......	41.0	59.0	......	.90	5.72	82.19	2.26	8.93	8,210	14,780
22004	1.0	A	3.1	37.6	53.0	6.3	2.24	......	......	......	......	7,455	13,420
		B	2.1	38.0	53.5	6.4	2.26	......	......	......	......	7,530	13,550
		C	......	38.8	54.7	6.5	2.31	......	......	......	......	7,695	13,850
		D	......	41.5	58.5	......	2.47	......	......	......	......	8,235	14,820
22005	.9	A	3.2	37.4	53.4	6.0	1.73	......	......	......	......	7,460	13,430
		B	2.3	37.7	53.9	6.1	1.75	......	......	......	......	7,530	13,550
		C	......	38.6	55.1	6.3	1.79	......	......	......	......	7,710	13,880
		D	......	41.2	58.8	......	1.91	......	......	......	......	8,220	14,800
22006	1.0	A	3.0	38.1	53.5	5.4	1.49	......	......	......	......	7,535	13,560
		B	2.0	38.5	54.0	5.5	1.50	......	......	......	......	7,605	13,690
		C	......	39.3	55.1	5.6	1.54	......	......	......	......	7,765	13,980
		D	......	41.6	58.4	......	1.63	......	......	......	......	8,225	14,810
22007	1.0	A	3.2	37.6	53.3	5.93	1.85	5.52	75.25	1.96	9.49	7,485	13,480
		B	2.3	37.9	53.8	5.99	1.87	5.46	75.97	1.98	8.73	7,560	13,610
		C	......	38.8	55.1	6.13	1.91	5.33	77.75	2.03	6.85	7,735	13,930
		D	......	41.3	58.7	......	2.03	5.68	82.83	2.16	7.30	8,240	14,830
22008	1.7	A	4.2	37.3	52.9	5.6	.85	......	......	......	......	7,440	13,390
		B	2.5	38.0	53.8	5.7	.86	......	......	......	......	7,565	13,620
		C	......	38.9	55.2	5.9	.89	......	......	......	......	7,765	13,980
		D	......	41.4	58.6	......	.95	......	......	......	......	8,250	14,850
22009	2.1	A	4.5	37.9	53.9	3.7	.80	......	......	......	......	7,585	13,660
		B	2.5	38.7	55.0	3.8	.82	......	......	......	......	7,745	13,950
		C	......	39.7	56.4	3.9	.84	......	......	......	......	7,945	14,300
		D	......	41.3	58.7	......	.87	......	......	......	......	8,270	14,880
22010	2.5	A	5.0	36.4	53.4	5.2	.83	......	......	......	......	7,415	13,350
		B	2.5	37.3	54.8	5.4	.85	......	......	......	......	7,605	13,690
		C	......	38.3	56.2	5.5	.87	......	......	......	......	7,805	14,050
		D	......	40.5	59.5	......	.92	......	......	......	......	8,260	14,870
22011	2.1	A	4.6	36.8	53.7	4.88	.83	5.57	75.59	1.77	11.36	7,490	13,490
		B	2.5	37.6	54.9	4.98	.85	5.45	77.20	1.81	9.71	7,650	13,770
		C	......	38.6	56.3	5.11	.87	5.30	79.20	1.85	7.67	7,850	14,130
		D	......	40.7	59.3	......	.92	5.59	83.47	1.95	8.07	8,275	14,890

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22012	1.1	A	3.5	39.1	55.3	2.1	1.03	......	......	......	......	7,855	14,140
		B	2.4	39.6	55.9	2.1	1.04	......	......	......	......	7,945	14,300
		C	......	40.6	57.2	2.2	1.07	......	......	......	......	8,140	14,650
		D	......	41.5	58.5	......	1.09	......	......	......	......	8,320	14,980
22013	1.0	A	3.6	39.8	54.7	1.9	.96	......	......	......	......	7,850	14,130
		B	2.6	40.2	55.3	1.9	.97	......	......	......	......	7,930	14,280
		C	......	41.3	56.8	1.9	1.00	......	......	......	......	8,145	14,660
		D	......	42.1	57.9	......	1.02	......	......	......	......	8,305	14,950
22014	1.1	A	3.5	39.7	54.7	2.06	1.03	5.77	78.70	2.00	10.44	7,875	14,180
		B	2.4	40.2	55.3	2.08	1.04	5.71	79.55	2.02	9.60	7,960	14,330
		C	......	41.2	56.7	2.13	1.07	5.58	81.56	2.07	7.59	8,160	14,690
		D	......	42.1	57.9	......	1.09	5.70	83.34	2.12	7.75	8,340	15,010
22015	1.6	A	4.3	38.3	55.6	1.8	1.11	......	......	......	......	7,805	14,050
		B	2.8	38.9	56.5	1.8	1.13	......	......	......	......	7,925	14,270
		C	......	40.0	58.2	1.8	1.16	......	......	......	......	8,155	14,680
		D	......	40.7	59.3	......	1.18	......	......	......	......	8,310	14,950
22016	2.3	A	5.2	37.3	55.0	2.5	1.30	......	......	......	......	7,650	13,770
		B	3.0	38.2	56.2	2.6	1.33	......	......	......	......	7,825	14,090
		C	......	39.3	58.0	2.7	1.37	......	......	......	......	8,070	14,520
		D	......	40.4	59.6	......	1.41	......	......	......	......	8,290	14,920
22017	1.9	A	4.6	38.0	55.3	2.13	1.19	5.72	77.51	2.01	11.44	7,705	13,870
		B	2.8	38.7	56.3	2.17	1.21	5.62	79.02	2.05	9.93	7,855	14,140
		C	......	39.8	58.0	2.23	1.25	5.45	81.28	2.11	7.68	8,080	14,550
		D	......	40.7	59.3	......	1.28	5.57	83.13	2.16	7.86	8,265	14,880
22018	1.2	A	4.0	38.4	55.6	2.0	1.01	......	......	......	......	7,795	14,040
		B	2.8	38.9	56.3	2.0	1.02	......	......	......	......	7,895	14,210
		C	......	40.0	57.9	2.1	1.05	......	......	......	......	8,120	14,610
		D	......	40.8	59.2	......	1.07	......	......	......	......	8,290	14,920
22019	1.5	A	4.0	39.5	53.9	2.6	.96	......	......	......	......	7,780	14,010
		B	2.4	40.2	54.7	2.7	.98	......	......	......	......	7,905	14,230
		C	......	41.2	56.1	2.7	1.00	......	......	......	......	8,100	14,580
		D	......	42.3	57.7	......	1.03	......	......	......	......	8,330	14,990
22020	1.4	A	3.9	39.1	54.7	2.32	.96	5.77	78.03	2.10	10.82	7,775	13,990
		B	2.6	39.6	55.5	2.35	.97	5.70	79.13	2.13	9.72	7,885	14,190
		C	......	40.7	56.9	2.41	1.00	5.55	81.21	2.19	7.64	8,090	14,560
		D	......	41.7	58.3	......	1.02	5.69	83.22	2.24	7.83	8,290	14,920
22021	1.6	A	3.2	36.7	48.5	11.6	2.78	......	......	......	......	6,985	12,580
		B	1.7	37.3	49.2	11.8	2.83	......	......	......	......	7,100	12,780
		C	......	37.9	50.1	12.0	2.87	......	......	......	......	7,220	13,000
		D	......	43.1	56.9	......	3.26	......	......	......	......	8,205	14,770
22022	1.9	A	3.6	37.0	48.0	11.4	2.92	......	......	......	......	7,010	12,620
		B	1.8	37.7	48.9	11.6	2.98	......	......	......	......	7,140	12,860
		C	......	38.4	49.8	11.8	3.03	......	......	......	......	7,270	13,090
		D	......	43.5	56.5	......	3.43	......	......	......	......	8,240	14,830
22023	1.6	A	3.5	37.1	47.5	11.9	2.86	......	......	......	......	6,950	12,510
		B	1.9	37.7	48.3	12.1	2.91	......	......	......	......	7,065	12,720
		C	......	38.5	49.2	12.3	2.96	......	......	......	......	7,205	12,970
		D	......	43.8	56.2	......	3.37	......	......	......	......	8,215	14,780
22024	1.7	A	3.5	36.6	48.4	11.54	2.80	5.17	69.81	1.30	9.38	6,995	12,590
		B	1.9	37.2	49.2	11.74	2.85	5.07	71.01	1.32	8.01	7,115	12,810
		C	......	37.9	50.1	11.96	2.90	4.95	72.37	1.35	6.47	7,250	13,050
		D	......	43.1	56.9	......	3.29	5.62	82.20	1.53	7.36	8,235	14,830
22025	1.3	A	3.6	37.9	53.4	5.1	.91	......	......	......	......	7,540	13,570
		B	2.4	38.3	54.1	5.2	.92	......	......	......	......	7,635	13,740
		C	......	39.3	55.4	5.3	.94	......	......	......	......	7,820	14,080
		D	......	41.5	58.5	......	.99	......	......	......	......	8,260	14,860
22026	1.5	A	3.8	38.4	51.9	5.9	1.14	......	......	......	......	7,470	13,440
		B	2.3	39.0	52.7	6.0	1.16	......	......	......	......	7,585	13,650
		C	......	39.9	54.0	6.1	1.19	......	......	......	......	7,765	13,980
		D	......	42.5	57.5	......	1.27	......	......	......	......	8,275	14,900

TENNESSEE—Continued.

CAMPBELL COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22027	1.4	A	3.7	38.0	52.7	5.58	1.00	5.52	75.52	1.75	10.63	7,505	13,510
		B	2.3	38.5	53.5	5.66	1.01	5.45	76.58	1.77	9.53	7,615	13,700
		C	....	39.5	54.7	5.79	1.04	5.31	78.41	1.82	7.63	7,795	14,030
		D	....	41.9	58.1	....	1.10	5.64	83.23	1.93	8.10	8,275	14,890
22028	1.4	A	3.4	39.0	49.2	8.4	2.35	....	....	....	....	7,295	13,140
		B	2.0	39.6	49.9	8.5	2.38	....	....	....	....	7,405	13,330
		C	....	40.4	51.0	8.6	2.43	....	....	....	....	7,555	13,600
		D	....	44.2	55.8	....	2.66	....	....	....	....	8,270	14,880
22029	2.0	A	4.1	36.9	48.2	10.8	2.39	....	....	....	....	7,025	12,650
		B	2.1	37.7	49.2	11.0	2.44	....	....	....	....	7,170	12,910
		C	....	38.5	50.2	11.3	2.49	....	....	....	....	7,325	13,180
		D	....	43.4	56.6	....	2.81	....	....	....	....	8,255	14,860
22030	2.0	A	4.1	36.2	47.6	12.1	3.66	....	....	....	....	6,850	12,330
		B	2.1	36.9	48.6	12.4	3.73	....	....	....	....	6,990	12,580
		C	....	37.7	49.7	12.6	3.82	....	....	....	....	7,145	12,870
		D	....	43.2	56.8	....	4.37	....	....	....	....	8,180	14,730
22031	2.4	A	4.4	35.7	47.8	12.1	2.22	....	....	....	....	6,850	12,330
		B	2.1	36.6	49.0	12.3	2.27	....	....	....	....	7,015	12,630
		C	....	37.3	50.1	12.6	2.32	....	....	....	....	7,165	12,890
		D	....	42.7	57.3	....	2.65	....	....	....	....	8,195	14,760
22032	2.0	A	4.0	37.1	48.1	10.84	2.65	5.27	70.32	1.42	9.50	7,020	12,640
		B	2.1	37.8	49.0	11.06	2.70	5.15	71.22	1.45	7.92	7,160	12,890
		C	....	38.6	50.1	11.29	2.76	5.03	73.25	1.48	6.19	7,315	13,170
		D	....	43.5	56.5	....	3.11	5.67	82,57	1.67	6.98	8,245	14,840

CLAIBORNE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21844	1.5	A	3.0	36.7	53.9	6.4	1.77	....	....	....	....	7,520	13,540
		B	1.6	37.2	54.7	6.5	1.80	....	....	....	....	7,630	13,740
		C	....	37.9	55.5	6.6	1.83	....	....	....	....	7,755	13,960
		D	....	40.5	59.5	....	1.96	....	....	....	....	8,305	14,950
21845	1.6	A	3.2	37.3	55.5	4.0	1.05	....	....	....	....	7,755	13,960
		B	1.6	37.9	56.4	4.1	1.07	....	....	....	....	7,885	14,190
		C	....	38.5	57.4	4.1	1.08	....	....	....	....	8,005	14,410
		D	....	40.2	59.8	....	1.13	....	....	....	....	8,350	15,030
21846	1.3	A	2.9	38.7	54.8	3.6	1.48	....	....	....	....	7,795	14,040
		B	1.6	39.3	55.5	3.6	1.50	....	....	....	....	7,900	14;220
		C	....	39.9	56.4	3.7	1.52	....	....	....	....	8,030	14,460
		D	....	41.4	58.6	....	1.58	....	....	....	....	8,335	15,010
21847	1.4	A	3.0	37.2	55.4	4.4	1.34	....	....	....	....	7,740	13,930
		B	1.6	37.7	56.2	4.5	1.36	....	....	....	....	7,850	14,130
		C	....	38.4	57.1	4.5	1.38	....	....	....	....	7,985	14,370
		D	....	40.2	59.8	....	1.45	....	....	....	....	8,360	15,050
21848	1.5	A	3.1	37.1	55.3	4.50	1.39	5.58	77.24	1.99	9.30	7,710	13,870
		B	1.6	37.7	56.1	4.57	1.41	5.50	78.38	2.02	8.12	7,820	14,080
		C	....	38.3	57.1	4.64	1.43	5.41	79.70	2.05	6.77	7,955	14,320
		D	....	40.2	59.8	....	1.50	5.67	83.58	2.15	7.10	8,340	15,010
21849	1.4	A	3.1	36.4	57.9	2.6	.69	....	....	....	....	7,880	14,190
		B	1.7	36.9	58.7	2.7	.70	....	....	....	....	7,990	14,380
		C	....	37.5	59.8	2.7	.71	....	....	....	....	8,130	14,630
		D	....	38.6	61.4	....	.73	....	....	....	....	8,360	15,040
21850	1.4	A	2.9	37.5	53.1	6.5	2.20	....	....	....	....	7,570	13,620
		B	1.5	38.0	53.9	6.6	2.23	....	....	....	....	7,675	13,820
		C	....	38.6	54.7	6.7	2.27	....	....	....	....	7,795	14,030
		D	....	41.4	58.6	....	2.43	....	....	....	....	8,355	15,040
21851	1.4	A	3.1	36.9	57.4	2.6	.78	....	....	....	....	7,900	14,220
		B	1.7	37.4	58.2	2.7	.79	....	....	....	....	8,010	14,420
		C	....	38.1	59.2	2.7	.80	....	....	....	....	8,150	14,670
		D	....	39.1	60.9	....	.82	....	....	....	....	8,380	15,090

TENNESSEE—Continued.

CLAIBORNE COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21852	1.4	A	3.0	37.2	55.9	3.94	1.16	5.56	78.50	1.93	8.91	7,790	14,020
		B	1.6	37.7	56.7	4.00	1.18	5.49	79.60	1.96	7.77	7,900	14,220
		C	....	38.3	57.6	4.06	1.20	5.39	80.92	1.99	6.44	8,030	14,460
		D	....	39.9	60.1	....	1.25	5.62	84.34	2.07	6.72	8,370	15,070
21857	1.5	A	3.3	37.8	54.3	4.6	1.15	....	....	....	....	7.690	13.840
		B	1.8	38.4	55.1	4.7	1.17	....	....	....	....	7,805	14,050
		C	....	39.1	56.1	4.8	1.19	....	....	....	....	7,955	14,320
		D	....	41.1	58.9	....	1.25	....	....	....	....	8,350	15,030
21858	1.4	A	3.2	38.3	55.8	2.7	1.06	....	....	....	....	7,875	14,180
		B	1.8	38.9	56.6	2.7	1.08	....	....	....	....	7,990	14,380
		C	....	39.6	57.7	2.7	1.10	....	....	....	....	8,140	14,650
		D	....	40.7	59.3	....	1.13	....	....	....	....	8,370	15,070
21859	1.4	A	3.2	39.4	54.4	3.0	1.31	....	....	....	....	7,860	14,150
		B	1.8	39.9	55.2	3.1	1.33	....	....	....	....	7,970	14,350
		C	....	40.7	56.2	3.1	1.35	....	....	....	....	8,120	14,620
		D	....	42.0	58.0	....	1.39	....	....	....	....	8,380	15,090
21860	1.3	A	3.0	38.4	55.5	3.1	1.25	....	....	....	....	7,860	14,150
		B	1.8	38.9	56.2	3.1	1.27	....	....	....	....	7,960	14,330
		C		39.6	57.2	3.2	1.29	....	....	....	....	8,105	14,590
		D	....	40.9	59.1	....	1.33	....	....	....	....	8,370	15,070
21861	1.4	A	3.2	38.3	55.1	3.43	1.19	5.66	78.10	1.94	9.73	7,815	14,070
		B	1.8	38.9	55.9	3.38	1.21	5.59	79.20	1.97	8.60	7,925	14,270
		C	....	39.6	56.9	3.49	1.23	5.48	80.65	2.00	7.15	8,070	14,530
		D	....	41.0	59.0	....	1.27	5.68	83.57	2.07	7.41	8,360	15,050
21862	1.4	A	3.2	37.5	56.7	2.6	.67	....	....	....	....	7,935	14,290
		B	1.8	38.0	57.5	2.7	.68	....	....	....	....	8,050	14,490
		C	....	38.7	58.6	2.7	.69	....	....	....	....	8,195	14,750
		D	....	39.8	60.2	....	.71	....	....	....	....	8,425	15,170
21863	1.1	A	3.0	38.1	54.6	4.3	1.72	....	....	....	....	7,770	13,990
		B	2.0	38.5	55.2	4.3	1.74	....	....	....	....	7,855	14,140
		C	....	39.3	56.3	4.4	1.77	....	....	....	....	8,010	14,420
		D	....	41.1	58.9	....	1.85	....	....	....	....	8,380	15,080
21864	1.1	A	2.9	37.9	56.1	3.1	.69	....	....	....	....	7,900	14,220
		B	1.9	38.3	56.7	3.1	.70	....	....	....	....	7,990	14,380
		C	....	39.0	57.8	3.2	.71	....	....	....	....	8,140	14,650
		D	....	40.3	59.7	....	.73	....	....	....	....	8,405	15,130
21865	1.5	A	3.4	37.7	55.1	3.8	1.54	....	....	....	....	7,775	14,000
		B	1.9	38.3	56.0	3.8	1.56	....	....	....	....	7,895	14,210
		C	....	39.0	57.1	3.9	1.59	....	....	....	....	8,050	14,490
		D	....	40.6	59.4	....	1.65	....	....	....	....	8,375	15,080
21866	1.3	A	3.1	37.8	55.7	3.39	1.19	5.62	78.49	1.99	9.32	7,840	14,110
		B	1.9	38.3	56.4	3.43	1.21	5.55	79.50	2.02	8.29	7,940	14,300
		C	....	39.1	57.4	3.50	1.23	5.44	81.02	2.05	6.76	8,095	14,570
		D	....	40.5	59.5	....	1.27	5.64	83.96	2.12	7.01	8,385	15,100
21867	1.5	A	3.2	37.2	57.1	2.5	.89	....	....	....	....	7,910	14,240
		B	1.8	37.7	57.9	2.6	.90	....	....	....	....	8,025	14,450
		C	....	38.4	59.0	2.6	.92	....	....	....	....	8,175	14,710
		D	....	39.4	60.6	....	.94	....	....	....	....	8,390	15,100
21868	1.2	A	3.0	38.9	54.6	3.5	.90	....	....	....	....	7,845	14,120
		B	1.8	39.4	55.3	3.5	.91	....	....	....	....	7,940	14,290
		C	....	40.1	56.3	3.6	.93	....	....	....	....	8,085	14,550
		D	....	41.6	58.4	....	.96	....	....	....	....	8,385	15,090
21869	1.0	A	2.8	36.4	57.1	3.7	1.01	....	....	....	....	7,825	14,090
		B	1.8	36.8	57.7	3.7	1.02	....	....	....	....	7,900	14,220
		C	....	37.5	58.8	3.7	1.04	....	....	....	....	8,050	14,490
		D	....	38.9	61.1	....	1.08	....	....	....	....	8,365	15,060
21870	1.2	A	2.9	37.7	56.2	3.22	.90	5.60	79.10	1.96	9.22	7,865	14,160
		B	1.7	38.2	56.8	3.26	.91	5.54	80.07	1.98	8.24	7,965	14,330
		C	....	38.8	57.9	3.32	.93	5.44	81.50	2.02	6.79	8,105	14,590
		D	....	40.2	59.8	....	.96	5.63	84.30	2.09	7.02	8,385	15,090

TENNESSEE—Continued.

CLAIBORNE COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22087	2.2	A	3.9	39.7	53.3	3.1	1.08					7,830	14,100
		B	1.8	40.6	54.4	3.2	1.10					8,005	14,410
		C		41.3	55.4	3.3	1.12					8,150	14,670
		D		42.7	57.3		1.16					8,425	15,160
22088	1.5	A	3.4	38.9	54.5	3.2	1.05					7,885	14,190
		B	1.9	39.5	55.3	3.3	1.07					8,005	14,410
		C		40.2	56.4	3.4	1.09					8,160	14,690
		D		41.6	58.4		1.13					8,445	15,200
22089	1.3	A	3.2	40.2	55.1	1.5	1.03					8,060	14,500
		B	1.9	40.8	55.8	1.5	1.04					8,165	14,700
		C		41.6	56.9	1.5	1.06					8,325	14,990
		D		42.2	57.8		1.08					8,460	15,220
22090	1.1	A	2.9	40.0	54.1	3.0	1.11					7,940	14,300
		B	1.8	40.4	54.8	3.0	1.12					8,030	14,460
		C		41.1	55.8	3.1	1.14					8,180	14,720
		D		42.5	57.5		1.18					8,440	15,200
22091	1.5	A	3.3	39.9	54.0	2.77	1.03	5.86	79.29	2.11	8.94	7,940	14,290
		B	1.8	40.5	54.9	2.81	1.05	5.78	80.52	2.14	7.70	8,060	14,510
		C		41.2	55.9	2.87	1.07	5.68	82.03	2.18	6.17	8,215	14,790
		D		42.5	57.5		1.10	5.85	84.45	2.24	6.36	8,455	15,220
22097	1.2	A	3.1	36.9	51.0	9.0	2.75					7,255	13,060
		B	1.9	37.3	51.7	9.1	2.78					7,340	13,210
		C		38.0	52.7	9.3	2.84					7,485	13,470
		D		41.9	58.1		3.12					8,250	14,850
22098	1.1	A	3.1	38.2	50.2	8.5	2.59					7,315	13,160
		B	2.0	38.6	50.8	8.6	2.62					7,395	13,310
		C		39.4	51.8	8.8	2.67					7,545	13,580
		D		43.2	56.8		2.93					8,275	14,890
22126	1.1	A	3.0	37.1	49.7	10.2	3.02					7,140	12,850
		B	1.9	37.5	50.2	10.4	3.05					7,215	12,990
		C	.	38.3	51.2	10.5	3.11					7,360	13,240
		D		42.8	57.2		3.48					8,225	14,810
22099	1.1	A	2.9	37.6	50.2	9.28	2.73	5.53	72.66	1.70	8.10	7,245	13,050
		B	1.8	38.1	50.7	9.38	2.76	5.47	73.48	1.72	7.19	7,330	13,190
		C		38.8	51.6	9.56	2.81	5.37	74.83	1.75	5.63	7,465	13,430
		D		42.9	57.1		3.11	5.94	32.74	1.93	6.28	8,250	14,850
22100	1.1	A	3.3	36.2	52.3	8.2	.94					7,335	13,200
		B	2.2	36.6	52.9	8.3	.95					7,410	13,340
		C		37.4	54.1	8.5	.97					7,585	13,650
		D		40.9	59.1		1.06					8,285	14,910
22101	1.1	A	3.3	34.5	53.2	9.0	.95					7,230	13,010
		B	2.3	34.9	53.7	9.1	.96					7,305	13,150
		C		35.7	55.0	9.3	.98					7,480	13,470
		D		39.3	60.7		1.03					8,250	14,850
22102	1.2	A	3.4	33.9	51.1	11.6	.88					6,965	12,540
		B	2.3	34.2	51.7	11.8	.89					7,050	12,690
		C		35.0	52.9	12.1	.91					7,210	12,980
		D		39.9	60.1		1.03					8,200	14,760
22103	1.5	A	3.5	36.5	52.0	8.0	.96					7,320	13,170
		B	2.0	37.0	52.9	8.1	.97					7,430	13,380
		C		37.8	53.9	8.3	.99					7,580	13,640
		D		41.2	58.8		1.08					8,265	14,880
22104	1.2	A	3.4	35.5	51.9	9.23	.95	5.61	72.51	1.85	9.85	7,215	12,990
		B	2.3	35.9	52.5	9.34	.96	5.55	73.40	1.87	8.88	7,306	13,150
		C		36.7	53.7	9.56	.98	5.41	75.07	1.92	7.06	7,470	13,450
		D		40.6	59.4		1.08	5.98	83.00	2.12	7.82	8,260	14,870
22105	1.8	A	3.4	38.6	50.5	7.5	2.61					7,385	13,290
		B	1.7	39.3	51.4	7.6	2.66					7,515	13,530
		C		39.9	52.3	7.8	2.70					7,645	13,760
		D		43.3	56.7		2.93					8,290	14,920

TENNESSEE—Continued.

CLAIBORNE COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22106	1.6	A	3.4	37.7	54.7	4.2	1.13					7,685	13,830
		B	1.9	38.3	55.5	4.3	1.15					7,805	14,050
		C		39.0	56.6	4.4	1.17					7,960	14,320
		D		40.8	59.2		1.22					8,320	14,980
22107	1.7	A	3.6	36.7	53.9	5.8	1.61					7,550	13,590
		B	1.9	37.4	54.8	5.9	1.64					7,680	13,820
		C		38.1	55.9	6.0	1.67					7,825	14,090
		D		40.5	59.5		1.78					8,325	14,990
22108	1.7	A	3.8	37.2	54.7	4.3	1.18					7,650	13,770
		B	2.1	37.9	55.7	4.3	1.20					7,785	14,020
		C		38.7	56.9	4.4	1.23					7,955	14,320
		D		40.5	59.5		1.29					8,325	14,990
22109	1.7	A	3.6	37.3	54.3	4.81	1.35	5.64	76.33	1.69	10.18	7,615	13,700
		B	1.9	38.0	55.2	4.89	1.37	5.55	77.62	1.72	8.85	7,740	13,940
		C		38.7	56.3	4.99	1.40	5.44	79.14	1.75	7.28	7,895	14,210
		D		40.7	59.3		1.47	5.73	83.29	1.84	7.67	8,305	14,950
22110	1.5	A	3.4	36.7	53.0	6.9	.81					7,465	13,440
		B	1.9	37.3	53.8	7.0	.82					7,580	13,640
		C		38.0	54.9	7.1	.84					7,725	13,910
		D		40.9	59.1		.90					8,320	14,980
22111	1.7	A	3.7	37.2	52.7	6.4	.76					7,460	13,430
		B	2.0	37.9	53.6	6.5	.77					7,590	13,660
		C		38.7	54.7	6.6	.79					7,750	13,950
		D		41.4	58.6		.85					8,300	14,940
22112	1.5	A	3.4	37.5	53.4	5.7	.81					7,545	13,590
		B	2.0	38.0	54.2	5.8	.82					7,660	13,780
		C		38.8	55.3	5.9	.84					7,810	14,060
		D		41.3	58.7		.89					8,305	14,950
22113	1.6	A	3.5	37.2	52.9	6.42	.84	5.62	75.19	1.91	10.02	7,475	13,450
		B	2.0	37.8	53.7	6.52	.85	5.54	76.37	1.94	8.78	7,590	13,660
		C		38.5	54.8	6.65	.87	5.42	77.93	1.98	7.15	7,745	13,940
		D		41.3	58.7		.93	5.81	83.48	2.12	7.66	8,295	14,930
22114	2.5	A	5.2	38.0	54.9	1.9	.95					7,650	13,770
		B	2.8	39.0	56.3	1.9	.97					7,850	14,130
		C		40.1	57.9	2.0	1.00					8,075	14,530
		D		40.9	59.1		1.02					8,240	14,830
22115	1.3	A	3.1	37.2	54.6	5.1	1.34					7,645	13,770
		B	1.8	37.7	55.3	5.2	1.36					7,750	13,950
		C		38.4	56.3	5.3	1.38					7,890	14,200
		D		40.6	59.4		1.46					8,330	15,000
22116	1.2	A	3.1	36.8	53.0	7.1	1.45					7,475	13,460
		B	1.9	37.3	53.6	7.2	1.47					7,570	13,630
		C		38.0	54.7	7.3	1.50					7,720	13,890
		D		41.0	59.0		1.62					8,330	14,990
22117	1.8	A	3.5	37.2	54.9	4.4	.99					7,660	13,790
		B	1.8	37.9	55.8	4.5	.97					7,800	14,040
		C		38.5	56.9	4.6	1.01					7,940	14,290
		D		40.4	59.6		1.05					8,320	14,980
22118	1.7	A	3.9	36.6	54.9	4.64	1.19	5.61	76.38	1.86	10.32	7,605	13,690
		B	2.2	37.3	55.8	4.72	1.21	5.51	77.71	1.90	8.95	7,740	13,930
		C		38.1	57.1	4.83	1.24	5.39	79.44	1.93	7.17	7,910	14,240
		D		40.0	60.0		1.30	5.66	83.48	2.03	7.53	8,315	14,960
22119	3.1	A	5.0	34.0	51.2	9.8	1.20					7,080	12,740
		B	1.9	35.1	52.8	10.2	1.24					7,310	13,150
		C		35.8	53.9	10.3	1.26					7,450	13,410
		D		39.9	60.1		1.41					8,310	14,960

TENNESSEE—Continued.

CLAIBORNE COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22120	1.5	A	3.5	37.9	55.3	3.3	0.93	....	....	....	....	7,805	14,050
		B	2.0	38.5	56.2	3.3	.94	....	....	....	....	7,920	14,260
		C	....	39.3	57.3	3.4	.96	....	....	....	....	8,085	14,560
		D	....	40.7	59.3	....	.99	....	....	....	....	8,370	15,060
22121	1.9	A	3.9	37.3	55.2	3.6	1.18	....	....	....	....	7,730	13,910
		B	2.0	38.0	56.3	3.7	1.19	....	....	....	....	7,880	14,180
		C	....	38.8	57.4	3.8	1.23	....	....	....	....	8,040	14,470
		D	....	40.4	59.6	....	1.28	....	....	....	....	8,355	15,040
22122	1.9	A	3.7	37.2	54.6	4.5	1.39	....	....	....	....	7,695	13,860
		B	1.9	37.9	55.6	4.6	1.42	....	....	....	....	7,845	14,120
		C	....	38.6	56.7	4.7	1.44	....	....	....	....	7,990	14,390
		D	....	40.5	59.5	....	1.51	....	....	....	....	8,390	15,100
22123	1.7	A	3.5	37.9	55.4	3.2	1.10	....	....	....	....	7,835	14,100
		B	1.8	38.6	56.3	3.3	1.12	....	....	....	....	7,970	14,340
		C	....	39.3	57.4	3.3	1.14	....	....	....	....	8,120	14,610
		D	....	....	....	....	1.18	....	....	....	....	8,395	15,120
22124	1.7	A	3.6	37.3	55.5	3.63	1.10	5.70	78.28	1.70	9.59	7,765	13,980
		B	1.9	38.0	56.4	3.69	1.12	5.61	79.66	1.73	8.19	7,900	14,220
		C	....	38.7	57.5	3.77	1.14	5.50	81.22	1.76	6.61	8,055	14,500
		D	....	40.2	59.8	....	1.18	5.72	84.40	1.83	6.87	8,375	15,070

FENTRESS COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20982	1.8	A	3.0	37.3	50.2	9.5	2.76	....	....	....	....	7,330	13,190
		B	1.2	38.0	51.1	9.7	2.81	....	....	....	....	7,460	13,430
		C	....	38.5	51.7	9.8	2.84	....	....	....	....	7,555	13,600
		D	....	42.6	57.4	....	3.15	....	....	....	....	8,375	15,080
20983	1.6	A	2.8	36.6	51.8	8.8	2.97	....	....	....	....	7,395	13,310
		B	1.3	37.2	52.6	8.9	3.02	....	....	....	....	7,515	13,520
		C	....	37.7	53.3	9.0	3.06	....	....	....	....	7,610	13,690
		D	....	41.4	58.6	....	3.36	....	....	....	....	8,360	15,050
20984	1.4	A	2.5	36.7	50.4	10.4	3.27	....	....	....	....	7,280	13,110
		B	1.1	37.2	51.1	10.6	3.32	....	....	....	....	7,385	13,300
		C	....	37.6	51.7	10.7	3.35	....	....	....	....	7,470	13,440
		D	....	42.1	57.9	....	3.75	....	....	....	....	8,365	15,050
20985	1.6	A	2.8	36.8	50.7	9.67	3.01	5.44	72.68	1.44	7.76	7,340	13,220
		B	1.2	37.5	51.5	9.83	3.06	5.35	73.85	1.46	6.45	7,460	13,430
		C	....	37.9	52.2	9.95	3.10	5.28	74.75	1.48	5.44	7,550	13,590
		D	....	42.1	57.9	....	3.44	5.86	83.01	1.64	6.05	8,385	15,090
20986	1.6	A	2.7	37.3	50.2	9.8	3.66	....	....	....	....	7,330	13,190
		B	1.1	37.9	51.0	10.0	3.72	....	....	....	....	7,445	13,410
		C	....	38.3	51.6	10.1	3.76	....	....	....	....	7,530	13,550
		D	....	42.6	57.4	....	4.18	....	....	....	....	8,375	15,080
20987	1.8	A	3.0	36.8	50.0	10.2	3.00	....	....	....	....	7,290	13,120
		B	1.2	37.5	51.0	10.3	3.05	....	....	....	....	7,425	13,360
		C	....	38.0	51.5	10.5	3.09	....	....	....	....	7,515	13,520
		D	....	42.4	57.6	....	3.45	....	....	....	....	8,390	15,100
20988	2.0	A	3.1	36.9	49.7	10.3	3.08	....	....	....	....	7,270	13,090
		B	1.1	37.6	50.8	10.5	3.14	....	....	....	....	7,415	13,350
		C	....	38.1	51.3	10.6	3.18	....	....	....	....	7,500	13,500
		D	....	42.6	57.4	....	3.56	....	....	....	....	8,390	15,110
20989	1.9	A	3.1	36.6	50.1	10.23	3.04	5.49	71.96	1.44	7.84	7,275	13,090
		B	1.2	37.3	51.1	10.43	3.10	5.38	73.35	1.47	6.27	7,415	13,350
		C	....	37.7	51.7	10.56	3.14	5.31	74.28	1.48	5.23	7,510	13,510
		D	....	42.2	57.8	....	3.51	5.94	83.05	1.65	5.85	8,395	15,110

TENNESSEE—Continued.

GRUNDY COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22359	1.8	A	3.4	29.2	58.4	9.0	0.64	......	......	......	......	7,355	13,240
		B	1.7	29.8	59.4	9.1	.65	......	......	......	......	7,485	13,470
		C	......	30.3	60.5	9.2	.66	......	......	......	......	7,615	13,710
		D	......	33.4	66.6	......	.73	......	......	......	......	8,390	15,100
22360	1.4	A	2.6	31.8	53.9	11.7	3.71	......	......	......	......	7,190	12,940
		B	1.3	32.2	54.7	11.8	3.76	......	......	......	......	7,290	13,120
		C	......	32.6	55.4	12.0	3.81	......	......	......	......	7,385	13,290
		D	......	37.1	62.9	......	4.33	......	......	......	......	8,390	15,100
22361	1.7	A	3.1	31.8	55.1	10.0	1.99	......	......	......	......	7,325	13,190
		B	1.4	32.4	56.1	10.1	2.03	......	......	......	......	7,455	13,420
		C	......	32.8	56.9	10.3	2.05	......	......	......	......	7,565	13,610
		D	......	36.6	63.4	......	2.29	......	......	......	......	8,430	15,170
22362	2.0	A	3.5	28.7	58.4	9.4	.63	......	......	......	......	7,320	13,170
		B	1.5	29.3	59.6	9.6	.64	......	......	......	......	7,470	13,450
		C	......	29.8	60.5	9.7	.65	......	......	......	......	7,580	13,650
		D	......	33.0	67.0	......	.72	......	......	......	......	8,400	15,120
22363	2.4	A	3.9	27.5	57.8	10.8	.60	......	......	......	......	7,145	12,860
		B	1.5	28.2	59.3	11.0	.61	......	......	......	......	7,325	13,180
		C	......	28.6	60.2	11.2	.62	......	......	......	......	7,435	13,380
		D	......	32.2	67.8	......	.70	......	......	......	......	8,375	15,080
22364	1.9	A	3.3	29.8	56.6	10.27	1.52	5.00	73.88	1.38	7.95	7,245	13,040
		B	1.4	30.4	57.7	10.47	1.55	4.88	75.29	1.41	6.40	7,385	13,290
		C	......	30.9	58.5	10.62	1.57	4.80	76.38	1.43	5.20	7,490	13,480
		D	......	34.6	65.4	......	1.76	5.37	85.45	1.60	5.82	8,380	15,090
22371	2.8	A	4.1	28.4	58.7	8.8	.55	......	......	......	......	7,280	13,110
		B	1.3	29.2	60.4	9.1	.57	......	......	......	......	7,495	13,490
		C	......	29.6	61.2	9.2	.57	......	......	......	......	7,595	13,670
		D	......	32.6	67.4	......	.63	......	......	......	......	8,360	15,050
22403	2.7	A	4.5	29.1	58.7	7.7	.63	......	......	......	......	7,335	13,200
		B	1.9	29.9	60.3	7.9	.65	......	......	......	......	7,535	13,560
		C	......	30.5	61.4	8.1	.66	......	......	......	......	7,680	13,820
		D	......	33.2	66.8	......	.72	......	......	......	......	8,350	15,030
22404	2.1	A	3.9	29.5	58.6	8.0	.56	......	......	......	......	7,360	13,240
		B	1.8	30.1	59.9	8.2	.57	......	......	......	......	7,515	13,530
		C	......	30.7	61.0	8.3	.58	......	......	......	......	7,655	13,780
		D	......	33.5	66.5	......	.63	......	......	......	......	8,350	15,030
22405	2.4	A	4.2	29.1	58.9	7.76	.59	5.04	75.26	1.54	9.81	7,350	13,230
		B	1.9	29.8	60.3	7.95	.60	4.89	77.10	1.58	7.88	7,530	13,550
		C	......	30.4	61.5	8.10	.62	4.77	78.59	1.61	6.31	7,675	13,820
		D	......	33.1	56.9	......	.67	5.19	85.51	1.75	6.88	8,350	15,030
22379	1.8	A	3.0	31.7	55.1	10.2	2.70	......	......	......	......	7,335	13,200
		B	1.2	32.3	56.1	10.4	2.75	......	......	......	......	7,475	13,450
		C	......	32.7	56.8	10.5	2.79	......	......	......	......	7,565	13,620
		D	......	36.5	63.5	......	3.12	......	......	......	......	8,460	15,220
22380	3.0	A	4.3	28.3	60.1	7.3	.61	......	......	......	......	7,460	13,420
		B	1.4	29.1	61.9	7.6	.63	......	......	......	......	7,690	13,840
		C	......	29.5	62.8	7.7	.64	......	......	......	......	7,795	14,040
		D	......	32.0	68.0	......	.69	......	......	......	......	8,445	15,200
22381	1.7	A	3.3	30.1	58.3	8.3	.86	......	......	......	......	7,425	13,370
		B	1.6	30.6	59.4	8.4	.88	......	......	......	......	7,555	13,600
		C	......	31.1	60.3	8.6	.89	......	......	......	......	7,680	13,820
		D	......	34.0	66.0	......	.97	......	......	......	......	8,395	15,120
22382	2.2	A	3.6	29.8	57.9	8.66	1.37	4.97	75.16	1.49	8.35	7,405	13,330
		B	1.5	30.5	59.2	8.85	1.40	4.84	76.84	1.52	6.55	7,570	13,630
		C	......	30.9	60.1	8.99	1.42	4.74	78.00	1.55	5.30	7,685	13,830
		D	......	34.0	66.0	......	1.56	5.21	85.71	1.70	5.82	8,445	15,200
22372	2.5	A	3.9	30.7	56.7	8.7	.77	......	......	......	......	7,250	13,050
		B	1.5	31.5	58.1	8.9	.79	......	......	......	......	7,435	13,380
		C	......	32.0	59.0	9.0	.80	......	......	......	......	7,545	13,580
		D	......	35.1	64.9	......	.88	......	......	......	......	8,295	14,930

TENNESSEE—Continued.

GRUNDY COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22373	1.9	A	2.9	30.1	58.1	8.9	0.72	......	......	......	......	7,360	13,250
		B	1.1	30.7	59.2	9.0	.73	......	......	......	......	7,500	13,500
		C	......	31.0	59.8	9.2	.74	......	......	......	......	7,580	13,650
		D	......	34.2	65.8	......	.81	......	......	......	......	8,345	15,020
22374	1.9	A	3.1	29.0	58.8	9.1	.82	......	......	......	......	7,390	13,300
		B	1.2	29.5	60.0	9.3	.84	......	......	......	......	7,530	13,560
		C	......	29.9	60.7	9.4	.85	......	......	......	......	7,625	13,730
		D	......	33.0	67.0	......	.94	......	......	......	......	8,420	15,150
22375	2.2	A	3.2	30.0	57.0	9.8	.79	......	......	......	......	7,285	13,110
		B	1.1	30.7	58.2	10.0	.81	......	......	......	......	7,445	13,400
		C	......	31.0	58.9	10.1	.82	......	......	......	......	7,525	13,550
		D	......	34.5	65.5	......	.91	......	......	......	......	8,375	15,080
22383	1.7	A	3.1	30.2	54.5	12.2	.87	......	......	......	......	7,120	12,810
		B	1.4	30.7	55.5	12.4	.89	......	......	......	......	7,245	13,040
		C	......	31.1	56.3	12.6	.90	......	......	......	......	7,350	13,230
		D	......	35.6	64.4	......	1.03	......	......	......	......	8,410	15,140
22384	1.6	A	3.1	30.0	57.6	9.3	1.16	......	......	......	......	7,340	13,210
		B	1.6	30.5	58.5	9.4	1.18	......	......	......	......	7,455	13,420
		C	......	31.0	59.4	9.6	1.20	......	......	......	......	7,575	13,640
		D	......	34.3	65.7	......	1.33	......	......	......	......	8,375	15,080
22385	1.0	A	2.6	29.6	55.0	12.8	1.18	......	......	......	......	7,070	12,730
		B	1.6	29.9	55.5	13.0	1.19	......	......	......	......	7,140	12,850
		C	......	30.4	56.4	13.2	1.21	......	......	......	......	7,260	13,070
		D	......	35.0	65.0	......	1.39	......	......	......	......	8,360	15,050
22386	1.5	A	3.1	29.8	57.4	9.7	1.02	......	......	......	......	7,310	13,150
		B	1.6	30.2	58.3	9.9	1.04	......	......	......	......	7,420	13,350
		C	......	30.7	59.2	10.1	1.05	......	......	......	......	7,540	13,570
		D	......	34.2	65.8	......	1.17	......	......	......	......	8,385	15,090
22387	1.4	A	2.9	29.7	56.4	11.01	1.10	4.76	73.30	1.52	8.31	7,220	12,990
		B	1.4	30.2	57.2	11.17	1.12	4.67	74.37	1.54	7.13	7,325	13,180
		C	......	30.6	58.1	11.33	1.13	4.57	75.47	1.56	5.94	7,430	13,380
		D	......	34.5	65.5	......	1.27	5.15	85.12	1.76	6.70	8,380	15,090
HAMILTON COUNTY.													
22160	1.9	A	2.8	27.8	61.6	7.8	0.98	......	......	......	......	7,670	13,810
		B	.9	28.3	62.8	8.0	1.00	......	......	......	......	7,815	14,070
		C	......	28.5	63.4	8.1	1.01	......	......	......	......	7,890	14,200
		D	......	31.1	68.9	......	1.10	......	......	......	......	8,580	15,450
22161	1.7	A	2.6	29.5	62.5	5.4	1.23	......	......	......	......	7,915	14,250
		B	1.0	30.0	63.5	5.5	1.25	......	......	......	......	8,050	14,490
		C	......	30.2	64.2	5.6	1.26	......	......	......	......	8,130	14,640
		D	......	32.1	67.9	......	1.33	......	......	......	......	8,610	15,500
22162	1.9	A	2.9	29.9	59.2	8.0	1.20	......	......	......	......	7,640	13,760
		B	1.0	30.5	60.4	8.1	1.22	......	......	......	......	7,790	14,020
		C	......	30.8	61.0	8.2	1.24	......	......	......	......	7,865	14,160
		D	......	33.6	66.4	......	1.35	......	......	......	......	8,570	15,430
22163	1.5	A	2.5	29.6	61.0	6.9	1.54	......	......	......	......	7,755	13,960
		B	1.0	30.1	61.9	7.0	1.56	......	......	......	......	7,870	14,170
		C	......	30.4	62.5	7.1	1.58	......	......	......	......	7,955	14,320
		D	......	32.7	67.3	......	1.70	......	......	......	......	8,560	15,410
22164	1.7	A	2.7	29.1	61.1	7.07	1.25	5.22	78.86	1.48	6.12	7,750	13,950
		B	1.0	29.6	62.2	7.19	1.27	5.12	80.23	1.51	4.68	7,885	14,190
		C	......	29.9	62.8	7.27	1.28	5.06	81.04	1.52	3.83	7,960	14,330
		D	......	32.3	67.7	......	1.38	5.46	87.39	1.64	4.13	8,585	15,460
22187	2.5	A	3.5	26.7	60.0	9.8	.81	......	......	......	......	7,440	13,390
		B	1.0	27.4	61.6	10.0	.83	......	......	......	......	7,625	13,730
		C	......	27.7	62.2	10.1	.84	......	......	......	......	7,705	13,870
		D	......	30.8	69.2	......	.93	......	......	......	......	8,575	15,430

TENNESSEE—Continued.

HAMILTON COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22188	2.3	A	3.4	27.4	58.7	10.5	0.99	....	....	....	....	7,385	13,290
		B	1.1	28.0	60.2	10.7	1.01	....	....	....	....	7,560	13,610
		C	....	28.3	60.8	10.9	1.02	....	....	....	....	7,640	13,750
		D	....	31.8	68.2	....	1.14	....	....	....	....	8,570	15,430
22189	2.4	A	3.4	27.1	59.4	10.10	.90	5.10	75.67	1.42	6.81	7,405	13,330
		B	1.0	27.8	60.9	10.35	.92	4.95	77.53	1.46	4.79	7,590	13,660
		C	....	28.0	61.5	10.46	.93	4.89	78.35	1.47	3.90	7,670	13,800
		D	....	31.3	68.7	....	1.04	5.46	87.50	1.64	4.36	8,565	15,420
22190	2.0	A	3.2	28.2	64.6	4.0	.69	....	....	....	....	7,950	14,310
		B	1.2	28.8	65.9	4.1	.70	....	....	....	....	8,115	14,600
		C	....	29.2	66.7	4.1	.71	....	....	....	....	8,210	14,780
		D	....	30.4	69.6	....	.74	....	....	....	....	8,565	15,420
22211	1.9	A	3.0	29.5	62.0	5.5	.72	....	....	....	....	7,870	14,170
		B	1.1	30.1	63.1	5.7	.73	....	....	....	....	8,020	14,440
		C	....	30.4	63.9	5.7	.74	....	....	....	....	8,110	14,600
		D	....	32.3	67.7	....	.79	....	....	....	....	8,605	15,490
22212	1.6	A	2.7	30.2	60.4	6.7	.66	....	....	....	....	7,710	13,880
		B	1.0	30.7	61.4	6.9	.67	....	....	....	....	7,840	14,110
		C	....	31.1	62.0	6.9	.68	....	....	....	....	7,925	14,260
		D	....	33.4	66.6	....	.73	....	....	....	....	8,510	15,320
22213	1.8	A	2.8	29.8	61.2	6.21	.69	5.26	79.43	1.30	7.11	7,790	14,020
		B	1.0	30.4	62.3	6.32	.70	5.15	80.85	1.32	5.66	7,930	14,270
		C	....	30.7	62.9	6.38	.71	5.10	81.66	1.34	4.81	8,005	14,410
		D	....	32.8	67.2	....	.76	5.45	87.22	1.43	5.14	8,550	15,390
22248	1.9	A	3.2	28.0	63.8	5.0	1.62	....	....	....	....	7,810	14,050
		B	1.4	28.5	65.0	5.1	1.65	....	....	....	....	7,960	14,330
		C	....	28.9	65.9	5.2	1.67	....	....	....	....	8,070	14,530
		D	....	30.5	69.5	....	1.76	....	....	....	....	8,510	15,320
22243	2.5	A	3.4	28.1	58.6	9.9	2.35	....	....	....	....	7,435	13,380
		B	1.0	28.8	60.1	10.1	2.41	....	....	....	....	7,625	13,720
		C	....	29.1	60.7	10.2	2.43	....	....	....	....	7,700	13,860
		D	....	32.4	67.6	....	2.71	....	....	....	....	8,570	15,430
22244	1.6	A	2.5	29.0	55.0	13.5	4.27	....	....	....	....	7,130	12,830
		B	.9	29.5	55.9	13.7	4.34	....	....	....	....	7,245	13,040
		C	....	29.7	56.4	13.9	4.38	....	....	....	....	7,310	13,160
		D	....	34.5	65.5	....	5.09	....	....	....	....	8,485	15,280
22245	1.8	A	2.7	29.8	57.6	9.9	2.53	....	....	....	....	7,475	13,460
		B	.9	30.3	58.7	10.1	2.58	....	....	....	....	7,610	13,700
		C	....	30.6	59.2	10.2	2.60	....	....	....	....	7,680	13,820
		D	....	34.1	65.9	....	2.90	....	....	....	....	8,550	15,390
22246	2.0	A	2.9	29.0	57.1	11.03	3.00	4.88	73.94	1.34	5.81	7,340	13,210
		B	.9	29.6	58.2	11.25	3.06	4.75	75.42	1.37	4.15	7,490	13,480
		C	....	29.9	58.8	11.35	3.09	4.69	76.11	1.38	3.38	7,555	13,600
		D	....	33.7	66.3	....	3.49	5.29	85.85	1.56	3.81	8,525	15,340
22247	3.1	A	4.3	25.7	59.2	10.8	1.59	....	....	....	....	7,215	12,990
		B	1.2	26.5	61.1	11.2	1.64	....	....	....	....	7,450	13,410
		C	....	26.8	61.9	11.3	1.66	....	....	....	....	7,540	13,570
		D	....	30.3	69.7	....	1.87	....	....	....	....	8,500	15,300
22249	1.7	A	2.6	30.4	58.3	8.7	1.49	....	....	....	....	7,685	13,830
		B	.8	31.0	59.3	8.9	1.52	....	....	....	....	7,820	14,070
		C	....	31.2	59.8	9.0	1.53	....	....	....	....	7,890	14,200
		D	....	34.3	65.7	....	1.68	....	....	....	....	8,665	15,590

MARION COUNTY.

22230	1.3	A	2.8	34.9	49.0	13.3	2.00	....	....	....	....	6,995	12,590
		B	1.6	35.4	49.6	13.4	2.03	....	....	....	....	7,085	12,760
		C	....	36.0	50.4	13.6	2.06	....	....	....	....	7,200	12,960
		D	....	41.6	58.4	....	2.39	....	....	....	....	8,335	15,010

TENNESSEE—Continued.

MARION COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22231	1.5	A	3.4	34.8	53.3	8.5	1.05					7,370	13,270
		B	1.9	35.4	54.1	8.6	1.07					7,480	13,470
		C		36.0	55.2	8.8	1.09					7,625	13,720
		D		39.5	60.5		1.19					8,355	15,040
22232	1.7	A	3.1	36.9	50.9	9.1	1.42					7,385	13,290
		B	1.4	37.6	51.8	9.2	1.44					7,515	13,520
		C		38.1	52.5	9.4	1.47					7,625	13,720
		D		42.1	57.9		1.62					8,410	15,140
22233	1.4	A	3.0	37.3	52.4	7.3	1.76					7,545	13,580
		B	1.6	37.9	53.1	7.4	1.78					7,655	13,780
		C		38.5	54.0	7.5	1.81					7,775	14,000
		D		41.6	58.4		1.96					8,410	15,130
22234	1.5	A	3.1	35.8	51.6	9.48	1.57	5.38	73.89	1.43	8.25	7,330	13,200
		B	1.6	36.4	52.4	9.62	1.89	5.30	75.00	1.45	7.04	7,440	13,400
		C		36.9	53.3	9.78	1.62	5.20	76.25	1.48	5.67	7,565	13,620
		D		41.0	59.0		1.80	5.76	84.52	1.64	6.28	8,385	15,100
22235	2.1	A	3.1	27.8	59.7	9.4	1.25					7,515	13,530
		B	1.1	28.4	60.9	9.6	1.28					7,675	13,820
		C		28.7	61.6	9.7	1.29					7,760	13,470
		D		31.8	68.2		1.43					8,595	15,470
22236	2.7	A	3.6	27.4	62.0	7.0	1.20					7,715	13,880
		B	1.0	28.1	63.7	7.2	1.23					7,925	14,260
		C		28.4	64.4	7.2	1.25					8,005	14,410
		D		30.6	69.4		1.35					8,625	15,530
22237	2.6	A	3.7	28.0	62.9	5.4	1.31					7,820	14,080
		B	1.1	28.8	64.6	5.5	1.34					8,025	14,450
		C		29.1	65.3	5.6	1.36					8,120	14,610
		D		30.8	69.2		1.44					8,595	15,470
22238	2.4	A	3.5	27.6	61.7	7.18	1.28	5.16	78.09	1.63	6.66	7,665	13,800
		B	1.1	28.3	63.2	7.36	1.31	5.01	80.04	1.67	4.61	7,860	14,150
		C		28.7	63.9	7.44	1.33	4.94	80.94	1.69	3.66	7,945	14,310
		D		30.9	69.1		1.44	5.34	87.45	1.83	3.94	8,585	15,460
22251	3.6	A	4.5	26.3	66.7	2.5	.73					8,125	14,620
		B	1.0	27.3	69.1	2.6	.76					8,425	15,170
		C		27.6	69.8	2.6	.76					8,505	15,310
		D		28.3	71.7		.78					8,735	15,730
22252	4.8	A	5.6	26.7	64.8	2.9	1.06					7,990	14,380
		B	1.0	28.0	68.0	3.0	1.11					8,385	15,100
		C		28.3	68.7	3.0	1.12					8,465	15,240
		D		29.2	70.8		1.15					8,730	15,710
22253	4.2	A	5.1	26.6	65.6	2.68	.90	5.35	81.92	1.46	7.69	8,050	14,490
		B	1.0	27.7	68.5	2.80	.94	5.10	85.48	1.52	4.16	8,400	15,120
		C		28.0	69.2	2.82	.95	5.04	86.31	1.54	3.34	8,485	15,270
		D		28.8	71.2		.98	5.19	88.81	1.58	3.44	8,730	15,710
22254	3.2	A	4.1	23.8	62.2	9.9	2.31					7,410	13,340
		B	.9	24.6	64.3	10.2	2.39					7,655	13,780
		C		24.8	64.9	10.3	2.41					7,725	13,900
		D		27.7	72.3		2.68					8,610	15,500
22255	2.7	A	3.6	23.0	61.8	11.6	2.71					7,255	13,060
		B	.9	23.7	63.5	11.9	2.78					7,455	13,420
		C		23.9	64.0	12.1	2.81					7,520	13,540
		D		27.2	72.8		3.20					8,555	15,400
22256	3.0	A	3.8	23.4	62.0	10.75	2.45	4.75	74.80	1.14	6.11	7,325	13,190
		B	.8	24.2	63.9	11.08	2.52	4.55	77.08	1.17	3.60	7,550	13,590
		C		24.3	64.5	11.17	2.55	4.50	77.74	1.18	2.86	7,615	13,710
		D		27.4	72.6		2.87	5.07	87.51	1.33	3.22	8,570	15,430
22257	1.8	A	2.7	25.1	61.3	10.9	2.87					7,390	13,300
		B	.9	25.5	62.5	11.1	2.92					7,530	13,550
		C		25.8	63.0	11.2	2.95					7,595	13,670
		D		29.0	71.0		3.32					8,555	15,400

TENNESSEE—Continued.

MARION COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22258	4.0	A	5.2	26.3	67.4	2.1	0.63	....	....	....	....	8,015	14,430
		B	1.3	26.3	70.2	2.2	.66	....	....	....	....	8,345	15,020
		C	....	26.7	71.1	2.2	.66	....	....	....	....	8,450	15,210
		D	....	27.3	72.7	....	.67	....	....	....	....	8,640	15,550
22267	1.8	A	3.3	28.5	60.0	8.2	.58	....	....	....	....	7,475	13,460
		B	1.5	29.0	61.1	8.4	.59	....	....	....	....	7,615	13,710
		C	....	29.5	62.0	8.5	.60	....	....	....	....	7,730	13,910
		D	....	32.2	67.8	....	.66	....	....	....	....	8,450	15,210
22268	1.8	A	3.3	28.6	59.7	8.4	.75	....	....	....	....	7,445	13,400
		B	1.6	29.1	60.7	8.6	.76	....	....	....	....	7,580	13,650
		C	....	29.6	61.7	8.7	.78	....	....	....	....	7,700	13,860
		D	....	32.4	67.6	....	.85	....	....	....	....	8,440	15,190
22269	2.2	A	3.6	28.1	60.0	8.3	1.11	....	....	....	....	7,445	13,400
		B	1.5	28.7	61.3	8.5	1.13	....	....	....	....	7,605	13,690
		C	....	29.1	62.3	8.6	1.15	....	....	....	....	7,725	13,900
		D	....	31.9	68.1	....	1.26	....	....	....	....	8,450	15,210
22270	1.7	A	3.2	28.9	59.5	8.4	.83	....	....	....	....	7,475	13,450
		B	1.5	29.4	60.6	8.5	.84	....	....	....	....	7,600	13,680
		C	....	29.8	61.5	8.7	.86	....	....	....	....	7,715	13,890
		D	....	32.7	67.3	....	.94	....	....	....	....	8,450	15,210
22271	1.9	A	3.4	28.2	60.1	8.32	.79	5.02	76.49	1.49	7.89	7,460	13,430
		B	1.5	28.7	61.3	8.48	.81	4.90	77.94	1.52	6.35	7,605	13,690
		C	....	29.1	62.3	8.61	.82	4.80	79.17	1.54	5.06	7,725	13,900
		D	....	31.9	68.1	....	.90	5.25	86.63	1.69	5.53	8,450	15,210
22370	2.5	A	3.8	28.4	59.2	8.6	1.14	....	....	....	....	7,320	13,180
		B	1.4	29.1	60.7	8.8	1.17	....	....	....	....	7,510	13,520
		C	....	29.6	61.5	8.9	1.19	....	....	....	....	7,610	13,700
		D	....	32.5	67.5	....	1.31	....	....	....	....	8,360	15,050
22398	1.6	A	2.9	29.8	56.6	10.7	2.59	....	....	....	....	7,270	13,090
		B	1.3	30.3	57.6	10.8	2.63	....	....	....	....	7,385	13,300
		C	....	30.7	58.3	11.0	2.67	....	....	....	....	7,485	13,470
		D	....	34.5	65.5	....	3.00	....	....	....	....	8,410	15,130
22399	1.8	A	3.0	29.7	57.5	9.8	1.26	....	....	....	....	7,310	13,160
		B	1.3	30.2	58.5	10.0	1.28	....	....	....	....	7,440	13,400
		C	....	30.6	59.3	10.1	1.30	....	....	....	....	7,540	13,570
		D	....	34.1	65.9	....	1.45	....	....	....	....	8,385	15,100
22400	1.7	A	2.8	30.7	54.7	11.8	4.26	....	....	....	....	7,150	12,870
		B	1.1	31.3	55.6	12.0	4.33	....	....	....	....	7,275	13,090
		C	....	31.6	56.2	12.2	4.38	....	....	....	....	7,355	13,240
		D	....	36.0	64.0	....	4.99	....	....	....	....	8,375	15,070
22401	1.8	A	3.2	29.5	58.3	9.0	.82	....	....	....	....	7,380	13,290
		B	1.5	30.0	59.4	9.1	.83	....	....	....	....	7,515	13,530
		C	....	30.5	60.3	9.2	.85	....	....	....	....	7,630	13,730
		D	....	33.6	66.4	....	.94	....	....	....	....	8,405	15,130
22402	1.7	A	3.1	29.6	57.0	10.31	2.22	4.93	73.92	1.41	7.21	7,285	13,120
		B	1.4	30.1	58.0	10.49	2.26	4.82	75.21	1.43	5.79	7,415	13,350
		C	....	30.6	58.8	10.64	2.29	4.74	76.27	1.45	4.61	7,520	13,530
		D	....	34.2	65.8	....	2.56	5.30	85.35	1.62	5.17	8,415	15,140

MORGAN COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21083	1.3	A	3.1	35.2	55.0	6.7	0.89	....	....	....	....	7,510	13,520
		B	1.8	35.7	55.7	6.8	.90	....	....	....	....	7,605	13,690
		C	....	36.3	56.8	6.9	.92	....	....	....	....	7,745	13,940
		D	....	39.0	61.0	....	.99	....	....	....	....	8,320	14,980
21084	1.6	A	2.8	36.9	54.5	5.8	2.92	....	....	....	....	7,740	13,930
		B	1.2	37.5	55.4	5.9	2.97	....	....	....	....	7,865	14,150
		C	....	38.0	56.1	5.9	3.00	....	....	....	....	7,960	14,330
		D	....	40.4	59.6	....	3.19	....	....	....	....	8,465	15,230

TENNESSEE—Continued.

MORGAN COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21085	1.7	A	2.9	37.5	54.9	4.7	2.63	......	......	......	......	7,850	14,130
		B	1.2	38.1	55.9	4.8	2.68	......	......	......	......	7,985	14,370
		C	......	38.6	56.6	4.8	2.71	......	......	......	......	8,085	14,550
		D	......	40.5	59.5	......	2.85	......	......	......	......	8,490	15,290
21086	1.7	A	2.8	37.3	55.3	4.6	2.26	......	......	......	......	7,850	14,130
		B	1.1	38.0	56.2	4.7	2.30	......	......	......	......	7,965	14,370
		C	......	38.4	56.9	4.7	2.33	......	......	......	......	8,075	14,540
		D	......	40.3	59.7	......	2.44	......	......	......	......	8,475	15,260
21087	1.6	A	2.9	37.3	54.7	5.10	2.63	5.61	77.44	1.73	7.49	7,885	14,050
		B	1.3	37.9	55.6	5.18	2.67	5.52	78.73	1.76	6.14	7,935	14,280
		C	......	38.4	56.4	5.25	2.71	5.45	79.72	1.78	5.09	8,035	14,460
		D	......	40.5	59.5	......	2.86	5.75	84.14	1.88	5.37	8,480	15,260
21088	.9	A	2.2	36.7	53.3	7.8	2.61	......	......	......	......	7,540	13,570
		B	1.4	37.0	53.8	7.8	2.63	......	......	......	......	7,605	13,690
		C	......	37.5	54.5	8.0	2.67	......	......	......	......	7,715	13,880
		D	......	40.8	59.2	......	2.90	......	......	......	......	8,380	15,080
21089	1.1	A	2.3	36.4	55.0	6.3	2.56	......	......	......	......	7,685	13,840
		B	1.2	36.8	55.6	6.4	2.59	......	......	......	......	7,775	13,990
		C	......	37.2	56.3	6.5	2.62	......	......	......	......	7,865	14,160
		D	......	39.8	60.2	......	2.80	......	......	......	......	8,410	15,140
21090	1.1	A	2.2	36.5	53.8	7.5	2.31	......	......	......	......	7,580	13,640
		B	1.1	36.9	54.4	7.6	2.33	......	......	......	......	7,660	13,790
		C	......	37.3	55.0	7.7	2.36	......	......	......	......	7,750	13,950
		D	......	40.4	59.6	......	2.56	......	......	......	......	8,390	15,100
21091	1.0	A	2.3	36.4	54.2	7.11	2.51	5.43	75.60	1.92	7.43	7,600	13,680
		B	1.3	36.8	54.7	7.18	2.54	5.37	76.37	1.94	6.60	7,680	13,820
		C	......	37.2	55.4	7.37	2.57	5.30	77.34	1.96	5.56	7,775	14,000
		D	......	40.2	59.8	......	2.77	5.72	83.40	2.11	6.00	8,385	15,090
21092	.8	A	2.1	34.6	50.0	13.3	2.05	......	......	......	......	7,085	12,750
		B	1.3	34.9	50.4	13.4	2.07	......	......	......	......	7,140	12,850
		C	......	35.3	51.1	13.6	2.09	......	......	......	......	7,230	13,120
		D	......	40.9	59.1	......	2.42	......	......	......	......	8,370	15,060
21093	1.0	A	2.2	36.4	53.6	7.8	2.32	......	......	......	......	7,530	13,560
		B	1.3	36.7	54.1	7.9	2.34	......	......	......	......	7,605	13,690
		C	......	37.2	54.8	8.0	2.37	......	......	......	......	7,705	13,870
		D	......	40.4	59.6	......	2.58	......	......	......	......	8,375	15,070
21094	1.2	A	2.4	37.0	54.8	5.8	3.60	......	......	......	......	7,725	13,910
		B	1.2	37.5	55.5	5.8	3.64	......	......	......	......	7,820	14,080
		C	......	37.9	56.2	5.9	3.69	......	......	......	......	7,915	14,250
		D	......	40.3	59.7	......	3.92	......	......	......	......	8,415	15,150
21095	1.0	A	2.2	37.2	55.0	5.6	2.69	......	......	......	......	7,775	14,000
		B	1.2	37.6	55.6	5.6	2.72	......	......	......	......	7,850	14,130
		C	......	38.1	56.2	5.7	2.75	......	......	......	......	7,950	14,310
		D	......	40.4	59.6	......	2.92	......	......	......	......	8,430	15,170
21096	1.0	A	2.3	36.3	53.3	8.10	2.61	5.36	74.94	1.89	7.10	7,550	13,590
		B	1.3	36.7	53.8	8.18	2.64	5.30	75.68	1.91	6.29	7,625	13,720
		C	......	37.2	54.5	8.29	2.67	5.23	76.66	1.93	5.22	7,725	13,900
		D	......	40.6	59.4	......	2.91	5.70	83.59	2.10	5.70	8,420	15,160
21099	2.6	A	3.3	39.1	52.9	4.7	3.29	......	......	......	......	7,890	14,200
		B	.8	40.1	54.3	4.8	3.38	......	......	......	......	8,095	14,580
		C	......	40.4	54.7	4.9	3.40	......	......	......	......	8,160	14,690
		D	......	42.5	57.5	......	3.57	......	......	......	......	8,580	15,440
21100	1.4	A	2.2	38.5	51.6	7.7	4.26	......	......	......	......	7,710	13,880
		B	.8	39.0	52.4	7.8	4.32	......	......	......	......	7,820	14,080
		C	......	39.3	52.8	7.9	4.35	......	......	......	......	7,890	14,180
		D	......	42.7	57.3	......	4.72	......	......	......	......	8,550	15,390
21101	1.0	A	1.8	39.3	52.1	6.8	3.55	......	......	......	......	7,820	14,080
		B	.8	39.7	52.6	6.9	3.52	......	......	......	......	7,905	14,230
		C	......	40.0	53.1	6.9	3.62	......	......	......	......	7,965	14,340
		D	......	43.0	57.0	......	3.89	......	......	......	......	8,560	15,400

TENNESSEE—Continued.

MORGAN COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21102	1.0	A	1.8	38.0	50.3	9.9	4.33	......	......	......	......	7,535	13,570
		B	.8	38.4	50.8	10.0	4.37	......	......	......	......	7,610	13,700
		C	......	38.7	51.2	10.1	4.41	......	......	......	......	7,670	13,810
		D	......	43.1	56.9	......	4.90	......	......	......	......	8,530	15,360
21103	1.1	A	1.9	38.5	51.5	8.14	4.04	5.60	75.26	1.79	5.17	7,695	13,850
		B	.8	38.9	52.1	8.23	4.09	5.53	76.13	1.81	4.21	7,780	14,010
		C	......	39.2	52.5	8.30	4.12	5.49	76.70	1.82	3.57	7,840	14,110
		D	......	42.7	57.3	......	4.49	5.99	83.64	1.98	3.90	8,550	15,390
21104	.9	A	1.6	38.4	51.4	8.6	5.01	......	......	......	......	7,660	13,790
		B	.7	38.7	51.9	8.7	5.06	......	......	......	......	7,730	13,910
		C	......	39.0	52.2	8.8	5.09	......	......	......	......	7,785	14,010
		D	......	42.7	57.3	......	5.58	......	......	......	......	8,530	15,360
21105	1.4	A	2.4	36.3	54.3	7.0	3.12	......	......	......	......	7,690	13,840
		B	1.1	36.8	55.0	7.1	3.16	......	......	......	......	7,795	14,030
		C	......	37.2	55.6	7.2	3.20	......	......	......	......	7,880	14,190
		D	......	40.1	59.9	......	3.45	......	......	......	......	8,490	15,290
21106	1.1	A	2.0	37.5	52.6	7.89	4.03	5.48	75.00	1.72	5.88	7,670	13,810
		B	.9	38.0	53.1	7.98	4.08	5.41	75.86	1.74	4.93	7,760	13,970
		C	......	38.3	53.6	8.05	4.11	5.37	76.53	1.76	4.18	7,830	14,090
		D	......	41.7	58.3	......	4.47	5.84	83.23	1.91	4.55	8,515	15,330
21145	1.5	A	3.0	39.6	53.2	4.2	1.33	......	......	......	......	7,790	14,030
		B	1.6	40.2	53.9	4.3	1.35	......	......	......	......	7,910	14,230
		C	......	40.8	54.8	4.4	1.37	......	......	......	......	8,035	14,460
		D	......	42.7	57.3	......	1.43	......	......	......	......	8,400	15,120
21146	3.2	A	4.5	37.0	47.4	11.1	4.35	......	......	......	......	7,040	12,670
		B	1.3	38.3	48.9	11.5	4.49	......	......	......	......	7,275	13,090
		C	......	38.8	49.6	11.6	4.56	......	......	......	......	7,370	13,270
		D	......	43.9	56.1	......	5.16	......	......	......	......	8,340	15,010
21147	2.1	A	3.5	36.6	55.4	4.5	1.42	......	......	......	......	7,775	13,990
		B	1.4	37.4	56.6	4.6	1.45	......	......	......	......	7,940	14,290
		C	......	37.9	57.4	4.7	1.47	......	......	......	......	8,055	14,500
		D	......	39.8	60.2	......	1.54	......	......	......	......	8,445	15,200
21148	3.3	A	4.3	35.2	55.9	4.6	1.26	......	......	......	......	7,775	14,000
		B	1.1	36.3	57.8	4.8	1.30	......	......	......	......	8,040	14,470
		C	......	36.7	58.5	4.8	1.32	......	......	......	......	8,125	14,630
		D	......	38.6	61.4	......	1.39	......	......	......	......	8,540	15,370
21149	2.6	A	3.4	35.7	53.9	7.0	2.71	......	......	......	......	7,700	13,860
		B	.8	36.7	55.3	7.2	2.78	......	......	......	......	7,905	14,230
		C	......	36.9	55.8	7.3	2.80	......	......	......	......	7,965	14,340
		D	......	39.8	60.2	......	3.02	......	......	......	......	8,590	15,460
21150	1.4	A	2.6	38.9	54.4	4.1	1.62	......	......	......	......	7,940	14,300
		B	1.2	39.4	55.2	4.2	1.64	......	......	......	......	8,060	14,500
		C	......	39.9	55.9	4.2	1.66	......	......	......	......	8,160	14,680
		D	......	41.6	58.4	......	1.73	......	......	......	......	8,515	15,330
21151	1.7	A	3.0	39.3	54.1	3.6	1.81	......	......	......	......	7,955	14,320
		B	1.3	40.0	55.0	3.7	1.84	......	......	......	......	8,090	14,560
		C	......	40.5	55.7	3.8	1.87	......	......	......	......	8,200	14,760
		D	......	42.1	57.9	......	1.94	......	......	......	......	8,520	15,340
21152	2.0	A	3.3	39.5	54.7	2.5	.67	......	......	......	......	8,020	14,440
		B	1.3	40.4	55.8	2.5	.68	......	......	......	......	8,185	14,730
		C	......	40.9	56.5	2.6	.69	......	......	......	......	8,295	14,940
		D	......	42.0	58.0	......	.71	......	......	......	......	8,515	15,330
21153	2.1	A	3.6	36.4	54.7	5.3	.77	......	......	......	......	7,730	13,910
		B	1.5	37.2	55.9	5.4	.79	......	......	......	......	7,895	14,220
		C	......	37.7	56.8	5.5	.80	......	......	......	......	8,015	14,430
		D	......	39.9	60.1	......	.85	......	......	......	......	8,485	15,270

TENNESSEE—Continued.

MORGAN COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21412	1.2	A	1.9	39.1	48.8	10.2	4.48	......	......	......	......	7,465	13,440
		B	.7	39.6	49.4	10.3	4.53	......	......	......	......	7,555	13,600
		C	......	39.9	49.7	10.4	4.57	......	......	......	......	7,615	13,700
		D	......	44.5	55.5	......	5.10	......	......	......	......	8,495	15,290
21413	.5	A	1.4	39.8	49.7	9.1	4.75	......	......	......	......	7,625	13,730
		B	.9	40.0	49.9	9.2	4.77	......	......	......	......	7,665	13,800
		C	......	40.3	50.4	9.3	4.82	......	......	......	......	7,735	13,920
		D	......	44.5	55.5	......	5.31	......	......	......	......	8,525	15,340
21414	.7	A	1.6	39.4	50.3	8.7	4.36	......	......	......	......	7,675	13,810
		B	.9	39.7	50.6	8.8	4.39	......	......	......	......	7,730	13,910
		C	......	40.0	51.1	8.9	4.43	......	......	......	......	7,795	14,030
		D	......	43.9	56.1	......	4.86	......	......	......	......	8,555	15,400
21415	.8	A	1.5	39.7	49.5	9.29	4.43	5.38	74.19	1.78	4.93	7,600	13,680
		B	.7	40.0	49.9	9.37	4.47	5.33	74.80	1.79	4.24	7,660	13,790
		C	......	40.3	50.3	9.43	4.50	5.29	75.33	1.81	3.64	7,715	13,890
		D	......	44.5	55.5	......	4.97	5.84	83.17	2.00	4.02	8,520	15,330
21416	.6	A	1.6	39.8	46.4	12.2	6.43	......	......	......	......	7,275	13,100
		B	1.0	40.1	46.7	12.2	6.47	......	......	......	......	7,320	13,180
		C	......	40.5	47.1	12.4	6.53	......	......	......	......	7,390	13,300
		D	......	46.2	53.8	......	7.45	......	......	......	......	8,435	15,180
21417	.8	A	1.6	40.5	51.1	6.8	4.39	......	......	......	......	7,770	13,980
		B	.8	40.9	51.5	6.8	4.42	......	......	......	......	7,830	14,090
		C	......	41.2	51.9	6.9	4.46	......	......	......	......	7,895	14,220
		D	......	44.3	55.7	......	4.79	......	......	......	......	8,480	15,270
21418	.7	A	1.5	40.0	48.9	9.56	5.40	5.25	72.83	1.70	5.26	7,525	13,540
		B	.8	40.3	49.3	9.63	5.44	5.21	73.35	1.71	4.66	7,575	13,640
		C	......	40.6	49.7	9.70	5.49	5.16	73.93	1.73	3.99	7,635	13,750
		D	......	45.0	55.0	......	6.07	5.71	81.87	1.92	4.43	8,455	15,220
21419	1.3	A	2.7	37.6	54.4	5.3	1.10	......	......	......	......	7,745	13,940
		B	1.4	38.1	55.2	5.3	1.11	......	......	......	......	7,850	14,130
		C	......	38.7	55.9	5.4	1.13	......	......	......	......	7,965	14,340
		D	......	40.9	59.1	......	1.19	......	......	......	......	8,420	15,160
21420	1.0	A	2.5	39.1	54.9	3.5	1.36	......	......	......	......	7,955	14,320
		B	1.5	39.5	55.5	3.5	1.37	......	......	......	......	8,035	14,470
		C	......	40.1	56.3	3.6	1.39	......	......	......	......	8,155	14,680
		D	......	41.6	58.4	......	1.44	......	......	......	......	8,460	15,230
21421	1.1	A	2.5	39.4	54.9	3.2	1.18	......	......	......	......	7,945	14,310
		B	1.4	39.8	55.5	3.3	1.19	......	......	......	......	8,040	14,470
		C	......	40.4	56.3	3.3	1.22	......	......	......	......	8,155	14,680
		D	......	41.8	58.2	......	1.26	......	......	......	......	8,430	15,170
21422	1.0	A	2.1	39.0	50.0	8.9	5.20	......	......	......	......	7,480	13,460
		B	1.2	39.4	50.4	9.0	5.25	......	......	......	......	7,550	13,590
		C	......	39.8	51.1	9.1	5.31	......	......	......	......	7,640	13,750
		D	......	43.8	56.2	......	5.84	......	......	......	......	8,405	15,130
21423	1.0	A	2.0	39.0	52.0	7.0	3.89	......	......	......	......	7,695	13,860
		B	1.0	39.4	52.5	7.1	3.93	......	......	......	......	7,775	14,000
		C	......	39.8	53.0	7.2	3.97	......	......	......	......	7,855	14,140
		D	......	42.9	57.1	......	4.28	......	......	......	......	8,460	15,230
21424	1.1	A	2.1	39.2	52.1	6.6	4.15	......	......	......	......	7,765	13,980
		B	.9	39.7	52.7	6.7	4.20	......	......	......	......	7,855	14,140
		C	......	40.1	53.2	6.7	4.24	......	......	......	......	7,930	14,270
		D	......	43.0	57.0	......	4.55	......	......	......	......	8,500	15,300
21425	1.0	A	2.3	37.0	56.6	4.1	.70	......	......	......	......	7,920	14,250
		B	1.3	37.3	57.2	4.2	.71	......	......	......	......	7,995	14,390
		C	......	37.8	57.9	4.3	.72	......	......	......	......	8,100	14,580
		D	......	39.5	60.5	......	.75	......	......	......	......	8,460	15,230
21426	1.0	A	2.4	40.2	54.7	2.7	.99	......	......	......	......	7,980	14,360
		B	1.4	40.7	55.2	2.7	1.00	......	......	......	......	8,060	14,510
		C	......	41.2	56.0	2.8	1.01	......	......	......	......	8,180	14,730
		D	......	42.4	57.6	......	1.04	......	......	......	......	8,410	15,140

TENNESSEE—Continued.

MORGAN COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21428	2.2	A	2.9	32.2	57.6	7.3	1.29	....	....	....	....	7,725	13,900
		B	.7	32.9	58.9	7.5	1.32	....	....	....	....	7,895	14,210
		C	....	33.2	59.3	7.5	1.33	....	....	....	....	7,955	14,320
		D	....	35.9	64.1	....	1.44	....	....	....	....	8,600	15,480

OVERTON COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20978	2.2	A	3.4	35.9	51.2	9.5	3.15	....	....	....	....	7,315	13,170
		B	1.3	36.7	52.3	9.7	3.22	....	....	....	....	7,480	13,460
		C	....	37.2	53.0	9.8	3.26	....	....	....	....	7,575	13,630
		D	....	41.3	58.7	....	3.61	....	....	....	....	8,395	15,120
20979	2.1	A	3.2	35.8	51.5	9.5	2.29	....	....	....	....	7,325	13,190
		B	1.2	36.5	52.6	9.7	2.34	....	....	....	....	7,480	13,460
		C	....	37.0	53.2	9.8	2.37	....	....	....	....	7,570	13,630
		D	....	41.0	59.0	....	2.63	....	....	....	....	8,395	15,110
20980	2.3	A	3.6	35.0	49.8	11.6	3.68	....	....	....	....	7,050	12,690
		B	1.3	35.9	50.9	11.9	3.77	....	....	....	....	7,220	12,990
		C	....	36.3	51.6	12.1	3.82	....	....	....	....	7,310	13,160
		D	....	41.3	58.7	....	4.34	....	....	....	....	8,315	14,970
20981	2.2	A	3.4	35.6	50.6	10.35	3.14	5.32	72.25	1.39	7.55	7,220	12,990
		B	1.3	36.4	51.7	10.58	3.21	5.18	73.86	1.42	5.75	7,380	13,280
		C	....	36.9	52.4	10.72	3.25	5.12	74.81	1.44	4.66	7,475	13,450
		D	....	41.3	58.7	....	3.64	5.74	83.79	1.61	5.22	8,370	15,070
20991	1.7	A	2.6	36.0	49.1	12.3	3.80	....	....	....	....	7,145	12,870
		B	1.0	36.6	49.9	12.5	3.87	....	....	....	....	7,270	13,090
		C	....	37.0	50.4	12.6	3.90	....	....	....	....	7,340	13,210
		D	....	42.3	57.7	....	4.46	....	....	....	....	8,400	15,120
20992	1.9	A	2.8	36.4	50.8	10.0	3.30	....	....	....	....	7,315	13,170
		B	1.0	37.1	51.7	10.2	3.37	....	....	....	....	7,455	13,420
		C	....	37.5	52.2	10.3	3.40	....	....	....	....	7,525	13,550
		D	....	41.8	58.2	....	3.79	....	....	....	....	8,390	15,100

PUTNAM COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20990	2.2	A	3.4	38.2	48.7	9.7	3.43	....	....	....	....	7,275	13,100
		B	1.2	39.1	49.8	9.9	3.51	....	....	....	....	7,440	13,390
		C	....	39.6	50.3	10.1	3.55	....	....	....	....	7,530	13,550
		D	....	44.0	56.0	....	3.95	....	....	....	....	8,375	15,070

RHEA COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22158	1.8	A	2.9	25.5	46.4	25.2	0.57	....	....	....	....	5,960	10,730
		B	1.1	26.0	47.2	25.7	.58	....	....	....	....	6,065	10,920
		C	....	26.3	47.8	25.9	.59	....	....	....	....	6,135	11,040
		D	....	35.5	64.5	....	.80	....	....	....	....	8,285	14,910
22159	1.1	A	2.0	33.4	57.0	7.6	3.70	....	....	....	....	7,670	13,810
		B	1.0	33.7	57.6	7.7	3.74	....	....	....	....	7,750	13,950
		C	....	34.1	58.1	7.8	3.78	....	....	....	....	7,830	14,100
		D	....	37.0	63.0	....	4.10	....	....	....	....	8,495	15,290
22165	1.2	A	2.0	29.4	53.1	15.5	.71	....	....	....	....	6,985	12,570
		B	.9	29.8	53.7	15.6	.72	....	....	....	....	7,070	12,720
		C	....	30.0	54.2	15.8	.72	....	....	....	....	7,130	12,840
		D	....	35.6	64.4	....	.86	....	....	....	....	8,470	15,240
22180	1.3	A	2.5	28.8	54.3	14.4	.91	....	....	....	....	7,005	12,610
		B	1.3	29.2	55.0	14.5	.92	....	....	....	....	7,090	12,770
		C	....	29.6	55.7	14.7	.91	....	....	....	....	7,185	12,940
		D	....	34.6	65.4	....	1.09	....	....	....	....	8,425	15,170

TENNESSEE—Continued.

RHEA COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22181	2.9	A	4.2	29.9	55.1	10.8	0.77					7,205	12,970
		B	1.3	30.9	56.7	11.1	.79					7,415	13,350
		C		31.2	57.5	11.3	.80					7,515	13,530
		D		35.2	64.8		.90					8,470	15,240
22182	1.2	A	2.5	31.5	53.8	12.2	2.00					7,170	12,900
		B	1.4	31.8	54.4	12.4	2.02					7,250	13,050
		C		32.3	55.2	12.5	2.05					7,355	13,240
		D		36.9	63.1		2.34					8.410	15,140
22183	1.2	A	2.5	30.7	56.7	10.1	1.31					7,400	13,320
		B	1.3	31.1	57.4	10.2	1.33					7,495	13,490
		C		31.5	58.1	10.4	1.34					7,590	13,660
		D		35.2	64.8		1.49					8,465	15,240
22184	1.6	A	3.0	30.2	55.0	11.82	1.25	4.90	72.96	1.40	7.67	7,200	12,960
		B	1.4	30.7	55.9	12.02	1.27	4.80	74.17	1.42	6.32	7,320	13,180
		C		31.1	56.7	12.18	1.29	4.71	75.20	1.44	5.18	7,420	13,360
		D		35.4	64.6		1.47	5.36	85.63	1.64	5.90	8,450	15,210

ROANE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21015	8.0	A	8.7	22.9	49.4	[a]19.0	0.52					6,100	10,980
		B	.8	24.8	53.7	20.7	.67					6,625	11,930
		C		25.1	54.1	20.8	.68					6,680	12,020
		D		31.6	68.4		.86					8,440	15,190
21016	.9	A	1.7	29.3	60.1	8.9	.53					7,630	13,740
		B	.9	29.5	60.6	9.0	.53					7,695	13,860
		C		29.8	61.1	9.1	.54					7,765	13,980
		D		32.7	67.3		.59					8,545	15,380
21017	.7	A	1.6	29.2	60.0	9.2	.46					7,580	13,650
		B	.9	29.4	60.4	9.3	.46					7,640	13,750
		C		29.6	61.0	9.4	.47					7,710	13,870
		D		32.7	67.3		.52					8,505	15,310
21018	1.2	A	2.2	29.5	59.4	8.9	.49					7,565	13,620
		B	1.0	29.9	60.2	8.9	.50					7,660	13,790
		C		30.2	60.8	9.0	.50					7,735	13,930
		D		33.2	66.8		.55					8,505	15,310
21023	.7	A	1.5	28.2	47.2	[a]23.1	2.02					6,350	11,430
		B	.9	28.4	47.5	23.2	2.03					6,390	11,500
		C		28.6	48.0	23.4	2.05					6,445	11,610
		D		37.4	62.6		2.68					8,420	15,150
21024	1.9	A	3.0	29.4	58.1	9.5	.79					7,405	13,330
		B	1.1	30.0	59.2	9.7	.80					7,545	13,580
		C		30.3	59.9	9.8	.81					7,630	13,730
		D		33.6	66.4		.90					8,460	15,230
21082	2.7	A	4.3	33.1	54.1	8.5	.48					7,290	13,130
		B	1.6	34.1	55.6	8.7	.49					7,495	13,490
		C		34.6	56.5	8.9	.50					7,620	13,710
		D		38.0	62.0		.55					8,360	15,050

SCOTT COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21154	1.8	A	3.7	37.9	50.9	7.5	1.91					7,365	13,260
		B	1.9	38.6	51.9	7.6	1.95					7,505	13,510
		C		39.4	52.9	7.7	1.98					7,650	13,770
		D		42.7	57.3		2.15					8,295	14,930

[a] High ash probably due to intimate mixture of some shale with the coal.

TENNESSEE—Continued.

SCOTT COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21155	1.8	A	3.8	39.4	51.1	5.7	1.99	......	......	......	......	7,540	13,570
		B	2.0	40.1	52.1	5.8	2.03	......	......	......	......	7,680	13,830
		C	......	40.9	53.2	5.9	2.07	......	......	......	......	7,840	14,110
		D	......	43.5	56.5	......	2.20	......	......	......	......	8,335	15,000
21156	1.8	A	3.8	38.5	51.2	6.52	1.93	5.60	74.32	1.83	9.80	7,445	13,400
		B	2.0	39.2	52.2	6.64	1.97	5.50	75.70	1.86	8.33	7,585	13,650
		C	......	40.0	53.2	6.77	2.01	5.38	77.22	1.90	6.72	7,735	13,930
		D	......	42.9	57.1	......	2.16	5.77	82.83	2.04	7.20	8,300	14,940
21219	2.2	A	3.8	39.5	48.6	8.1	4.27	......	......	......	......	7,310	13,160
		B	1.6	40.4	49.7	8.3	4.37	......	......	......	......	7,475	13,460
		C	......	41.1	50.5	8.4	4.44	......	......	......	......	7,595	13,680
		D	......	44.8	55.2	......	4.85	......	......	......	......	8,295	14,940
21220	2.2	A	3.6	39.7	44.6	12.1	6.02	......	......	......	......	6,970	12,540
		B	1.4	40.6	45.7	12.3	6.15	......	......	......	......	7,120	12,820
		C	......	41.2	46.3	12.5	6.24	......	......	......	......	7,225	13,010
		D	......	47.0	53.0	......	7.13	......	......	......	......	8,260	14,870
21221	2.2	A	3.6	39.6	46.7	10.12	5.13	5.42	70.08	1.63	7.62	7,150	12,870
		B	1.5	40.5	47.7	10.34	5.24	5.29	71.63	1.67	5.83	7,310	13,160
		C	......	41.1	48.4	10.50	5.32	5.21	72.71	1.69	4.57	7.420	13,350
		D	......	45.9	54.1	......	5.94	5.82	81.24	1.89	5.11	8,290	14,920
21218	7.5	A	9.0	36.5	42.7	11.83	4.52	5.59	63.48	1.55	13.03	6,530	11,760
		B	1.7	39.4	46.1	12.78	4.88	5.14	68.61	1.67	6.92	7,060	12,710
		C	......	40.1	46.9	13.00	4.97	5.04	69.76	1.70	5.53	7,180	12.920
		D	......	46.1	53.9	......	5.71	5.79	80.18	1.95	6.37	8,250	14,850
21222	3.4	A	4.6	38.0	48.8	8.6	3.61	......	......	......	......	7,295	13,130
		B	1.2	39.3	50.5	9.0	3.74	......	......	......	......	7,550	13,590
		C	......	39.8	51.1	9.1	3.78	......	......	......	......	7,645	13,760
		D	......	43.8	56.2	......	4.16	......	......	......	......	8,405	15,130
21223	2.4	A	3.6	39.3	49.1	8.0	3.34	......	......	......	......	7,465	13,440
		B	1.2	40.3	50.3	8.2	3.42	......	......	......	......	7,650	13,770
		C	......	40.8	50.9	8.3	3.47	......	......	......	......	7,745	13,940
		D	......	44.5	55.5	......	3.79	......	......	......	......	8,450	15,210
21224	2.7	A	4.2	36.5	55.0	4.3	.71	......	......	......	......	7,680	13,820
		B	1.6	37.5	56.5	4.4	.73	......	......	......	......	7,890	14,200
		C	......	38.1	57.4	4.5	.74	......	......	......	......	8,020	14,440
		D	......	39.9	60.1	......	.77	......	......	......	......	8,395	15,110
21225	1.9	A	3.6	37.1	54.4	4.9	.81	......	......	......	......	7,700	13,860
		B	1.8	37.8	55.4	5.0	.83	......	......	......	......	7,850	14,130
		C	......	38.5	56.4	5.1	.84	......	......	......	......	7,990	14,380
		D	......	40.6	59.4	......	.88	......	......	......	......	8,420	15,150
21226	2.3	A	3.9	36.7	54.8	4.6	.79	......	......	......	......	7,720	13,890
		B	1.7	37.5	56.1	4.7	.81	......	......	......	......	7,900	14,220
		C	......	38.2	58.0	4.8	.82	......	......	......	......	8,030	14,460
		D	......	40.1	59.9	......	.86	......	......	......	......	8,440	15,190
21227	2.4	A	4.1	37.0	54.6	4.3	.77	......	......	......	......	7,710	13,880
		B	1.7	37.9	56.0	4.4	.79	......	......	......	......	7,900	14,220
		C	......	38.6	57.0	4.4	.80	......	......	......	......	8,040	14,470
		D	......	40.4	59.6	......	.84	......	......	......	......	8,415	15,150
21228	1.2	A	2.7	39.7	48.4	9.2	3.75	......	......	......	......	7,405	13,330
		B	1.5	40.2	48.9	9.4	3.79	......	......	......	......	7,490	13.480
		C	......	40.8	49.7	9.5	3.85	......	......	......	......	7,605	13,690
		D	......	45.1	54.9	......	4.25	......	......	......	......	8,405	15,130
21229	1.2	A	3.1	38.2	54.6	4.1	1.05	......	......	......	......	7,830	14,090
		B	2.0	38.6	55.3	4.1	1.06	......	......	......	......	7,920	14,260
		C	......	39.4	56.4	4.2	1.08	......	......	......	......	8,080	14.550
		D	......	41.1	58.9	......	1.13	......	......	......	......	8,435	15,190
21272	1.8	A	2.9	36.1	55.6	5.41	1.87	5.60	77.09	2.00	8.03	7,690	13.840
		B	1.1	36.8	56.6	5.51	1.90	5.50	78.52	2.04	6.53	7,830	14,100
		C	......	37.2	57.2	5.57	1.93	5.44	79.39	2.06	5.61	7,920	14,250
		D	......	39.4	60.6	......	2.04	5.76	84.07	2.18	5.95	8,385	15,100

TENNESSEE—Continued.

SCOTT COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating valu	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
21314	2.4	A	3.8	36.2	56.0	4.0	0.86	......	......	......	......	7,845	14,12
		B	1.4	37.1	57.4	4.1	.91	......	......	......	......	8,040	14,47
		C	......	37.6	58.2	4.2	.92	......	......	......	......	8,155	14,6
		D	......	39.3	60.7	......	.96	......	......	......	......	8,510	15,32
21315	2.3	A	3.6	35.3	55.6	5.5	1.04	......	......	......	......	7,710	13,9
		B	1.3	36.2	56.9	5.6	1.06	......	......	......	......	7,895	14,21
		C	......	36.7	57.6	5.7	1.08	......	......	......	......	8,000	14,40
		D	......	38.9	61.1	......	1.15	......	......	......	......	8,485	15,28
21316	2.8	A	4.3	36.4	55.2	4.1	1.20	......	......	......	......	7,705	13,8
		B	1.6	37.4	56.8	4.2	1.23	......	......	......	......	7,925	14,26
		C	......	38.0	57.7	4.3	1.25	......	......	......	......	8,050	14,49
		D	......	39.7	60.3	......	1.31	......	......	......	......	8,405	15,13

SEQUATCHIE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
22239	1.4	A	2.6	29.7	59.0	8.7	1.12	......	......	......	......	7,520	13,54
		B	1.2	30.2	59.8	8.8	1.14	......	......	......	......	7,630	13,73
		C	......	30.5	60.6	8.9	1.15	......	......	......	......	7,725	13,90
		D	......	33.5	66.5	......	1.26	......	......	......	......	8,480	15,26
22240	1.7	A	2.8	30.1	57.2	9.9	1.22	......	......	......	......	7,445	13,40
		B	1.2	30.6	58.2	10.0	1.24	......	......	......	......	7,575	13,63
		C	......	31.0	58.8	10.2	1.26	......	......	......	......	7,660	13,79
		D	......	34.5	65.5	......	1.40	......	......	......	......	8,530	15,35
22241	1.5	A	2.7	29.4	56.9	11.0	1.60	......	......	......	......	7,320	13,17
		B	1.2	29.9	57.7	11.2	1.62	......	......	......	......	7,430	13,37
		C	......	30.2	58.5	11.3	1.64	......	......	......	......	7,520	13,54
		D	......	34.1	65.9	......	1.85	......	......	......	......	8,480	15,27
22242	1.5	A	2.8	29.5	57.9	9.79	1.27	4.96	75.53	1.44	7.01	7,425	13,37
		B	1.3	30.0	58.8	9.94	1.29	4.86	76.71	1.46	5.74	7,540	13,57
		C	......	30.4	59.5	10.07	1.31	4.78	77.69	1.48	4.67	7,635	13,73
		D	......	33.8	66.2	......	1.46	5.32	86.39	1.65	5.18	8,490	15,29

WHITE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units
22365	1.6	A	3.0	38.1	51.1	7.8	2.67	......	......	......	......	7,490	13,48
		B	1.4	38.8	51.9	7.9	2.71	......	......	......	......	7,610	13,70
		C	......	39.3	52.6	8.1	2.75	......	......	......	......	7,720	13,90
		D	......	42.8	57.2	......	2.99	......	......	......	......	8,395	15,12
22366	2.0	A	3.5	37.7	51.9	6.9	2.60	......	......	......	......	7,510	13,52
		B	1.5	38.5	53.0	7.0	2.65	......	......	......	......	7,665	13,80
		C	......	39.1	53.8	7.1	2.69	......	......	......	......	7,780	14,01
		D	......	42.1	57.9	......	2.90	......	......	......	......	8,375	15,08
22367	1.5	A	2.9	38.3	50.6	8.2	3.04	......	......	......	......	7,420	13,35
		B	1.5	38.9	51.3	8.3	3.09	......	......	......	......	7,530	13,55
		C	......	39.5	52.1	8.4	3.13	......	......	......	......	7,645	13,76
		D	......	43.1	56.9	......	3.42	......	......	......	......	8,350	15,03
22368	1.7	A	3.2	38.3	50.9	7.60	2.80	5.45	74.45	1.19	8.51	7,455	13,42
		B	1.5	39.0	51.8	7.73	2.85	5.35	75.75	1.21	7.11	7,585	13,65
		C	......	39.6	52.6	7.85	2.89	5.27	76.87	1.23	5.89	7,695	13,85
		D	......	42.9	57.1	......	3.14	5.72	83.42	1.33	6.39	8,350	15,03
22369	1.4	A	2.7	39.8	47.5	10.0	3.36	......	......	......	......	7,355	13,24
		B	1.4	40.4	48.1	10.1	3.41	......	......	......	......	7,455	13,42
		C	......	40.9	48.8	10.3	3.45	......	......	......	......	7,560	13,61
		D	......	45.6	54.4	......	3.85	......	......	......	......	8,430	15,17
22393	1.8	A	3.4	39.5	46.8	10.3	4.09	......	......	......	......	7,225	13,01
		B	1.6	40.3	47.6	10.5	4.16	......	......	......	......	7,360	13,24
		C	......	41.0	48.4	10.6	4.23	......	......	......	......	7,480	13,46
		D	......	45.8	54.2	......	4.73	......	......	......	......	8,370	15,06

TENNESSEE—Continued.

WHITE COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22394	1.3	A	2.8	40.4	46.6	10.2	3.28	....	....	....	....	7,310	13,160
		B	1.4	41.0	47.2	10.4	3.32	....	....	....	....	7,410	13,330
		C	....	41.6	47.9	10.5	3.37	....	....	....	....	7,515	13,530
		D	....	46.5	53.5	....	3.77	....	....	....	....	8,400	15,120
22395	1.3	A	2.8	39.6	46.4	11.2	5.06	....	....	....	....	7,205	12,970
		B	1.5	40.1	47.0	11.4	5.13	....	....	....	....	7,300	13,140
		C	....	40.7	47.8	11.5	5.20	....	....	....	....	7,410	13,340
		D	....	46.0	54.0	....	5.88	....	....	....	....	8,380	15,080
22396	1.8	A	3.4	38.8	47.8	10.0	3.84	....	....	....	....	7,230	13,020
		B	1.6	39.5	48.7	10.2	3.91	....	....	....	....	7,365	13,260
		C	....	40.1	49.5	10.4	3.97	....	....	....	....	7,485	13,470
		D	....	44.8	55.2	....	4.43	....	....	....	....	8,355	15,040
22397	1.6	A	3.0	39.7	46.9	10.40	4.12	5.29	71.00	1.41	7.78	7,250	13,050
		B	1.4	40.3	47.7	10.57	4.19	5.20	72.13	1.43	6.48	7,370	13,260
		C	....	40.9	48.4	10.72	4.25	5.10	73.21	1.45	5.27	7,480	13,460
		D	....	45.8	54.2	....	4.76	5.71	82.00	1.62	5.91	8,375	15,080
22388	2.8	A	4.0	35.8	48.5	11.7	3.90	....	....	....	....	7,085	12,560
		B	1.2	36.8	49.9	12.1	4.01	....	....	....	....	7,290	13,120
		C	....	37.3	50.5	12.2	4.06	....	....	....	....	7,380	13,280
		D	....	42.5	57.5	....	4.62	....	....	....	....	8,405	15,130
22389	1.1	A	2.4	37.7	49.2	10.7	3.50	....	....	....	....	7,340	13,210
		B	1.3	38.1	49.8	10.8	3.54	....	....	....	....	7,425	13,360
		C	....	38.6	50.4	11.0	3.59	....	....	....	....	7,525	13,540
		D	....	43.4	56.6	....	4.03	....	....	....	....	8,450	15,210
22390	4.4	A	5.6	35.4	47.5	11.5	4.41	....	....	....	....	6,965	12,540
		B	1.3	37.0	49.7	12.0	4.61	....	....	....	....	7,285	13,110
		C	....	37.5	50.3	12.2	4.67	....	....	....	....	7,375	13,280
		D	....	42.7	57.3	....	5.32	....	....	....	....	8,400	15,120
22391	2.1	A	3.4	36.1	46.9	13.6	4.82	....	....	....	....	6,975	12,560
		B	1.3	36.9	48.0	13.8	4.92	....	....	....	....	7,130	12,830
		C	....	37.4	48.6	14.0	4.99	....	....	....	....	7,220	13,000
		D	....	43.5	56.5	....	5.80	....	....	....	....	8,400	15,120
22392	2.6	A	3.8	36.2	48.1	11.93	4.22	5.22	69.72	1.33	7.58	7,090	12,760
		B	1.3	37.1	49.4	12.25	4.33	5.06	71.58	1.37	5.41	7,275	13,100
		C	....	37.6	50.0	12.40	4.39	4.98	72.49	1.38	4.36	7,370	13,270
		D	....	42.9	57.1	....	5.01	5.69	82.75	1.58	4.97	8,415	15,150

UTAH.

CARBON COUNTY.

19680	3.2	A	6.2	40.8	48.5	4.55	0.37	5.57	71.47	1.37	16.67	7,040	12,670
		B	3.1	42.1	50.1	4.70	.38	5.39	73.79	1.41	14.33	7,270	13,090
		C	....	43.5	51.7	4.85	.39	5.21	76.16	1.46	11.93	7,505	13,510
		D	....	45.7	54.3	....	.41	5.48	80.04	1.53	12.54	7,885	14,200
19711	2.2	A	6.0	38.8	49.1	6.1	.49	....	....	....	....	6,910	12,430
		B	3.9	39.7	50.2	6.2	.50	....	....	....	....	7,065	12,710
		C	....	41.3	52.2	6.5	.52	....	....	....	....	7,350	13,230
		D	....	44.2	55.8	....	.56	....	....	....	....	7,855	14,140
19681	2.0	A	5.0	43.7	46.5	4.80	.41	5.83	71.93	1.31	15.72	7,125	12,820
		B	3.1	44.6	47.4	4.90	.42	5.72	73.39	1.34	14.23	7,270	13,080
		C	....	46.0	49.0	5.05	.43	5.55	75.72	1.38	11.87	7,500	13,500
		D	....	48.4	51.6	....	.45	5.85	79.75	1.45	12.50	7,895	14,220
19712	.9	A	5.1	41.8	47.4	5.7	.55	....	....	....	....	7,080	12,740
		B	4.2	42.2	47.9	5.7	.56	....	....	....	....	7,145	12,860
		C	....	44.1	49.9	6.0	.58	....	....	....	....	7,455	13,420
		D	....	46.9	53.1	....	.62	....	....	....	....	7,930	14,270

UTAH—Continued.

CARBON COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19682	1.5	A	4.4	44.1	46.6	4.94	0.68	5.64	72.34	1.29	15.11	7,125	12,830
		B	3.0	44.8	47.2	5.01	.69	5.56	73.42	1.31	14.01	7,230	13,020
		C		46.1	48.7	5.17	.71	5.39	75.68	1.35	11.70	7,455	13,420
		D		48.6	51.4		.75	5.68	79.80	1.42	12.35	7,860	14,150
19710	1.8	A	4.0	41.1	50.5	4.4	.65					7,250	13,050
		B	2.3	41.8	51.4	4.5	.66					7,385	13,290
		C		42.8	52.6	4.6	.68					7,555	13,600
		D		44.9	55.1		.71					7,925	14,260
19702	.7	A	4.7	41.3	47.6	6.4	.41					7,015	12,630
		B	4 0	41.6	48.0	6.4	.41					7,060	12,710
		C		43.4	49.9	6.7	.43					7,360	13,240
		D		46.5	53.5		.46					7,885	14,190
19706	.7	A	4.0	45.7	44.7	5.6	.54					7,175	12,920
		B	3.3	46.0	45.0	5.7	.54					7,225	13,000
		C		47.6	46.5	5.9	.56					7,475	13,460
		D		50.6	49.4		.59					7,940	14,290
19843	1.3	A	3.7	42.8	48.2	5.31	.33	5.78	73.94	1.26	13.38	7,325	13,190
		B	2.4	43.4	48.8	5.38	.33	5.71	74.94	1.28	12.36	7,425	13,360
		C		44.4	50.1	5.51	.34	5.58	76.78	1.31	10.48	7,605	13,690
		D		47.0	53.0		.36	5.91	81.26	1.39	11.08	8,050	14,490
19845	2.6	A	4.8	40.3	45.9	8.99	.65	5.61	69.62	1.35	13.78	6,945	12,500
		B	2.2	41.4	47.2	9.23	.67	5.46	71.48	1.39	11.77	7,130	12,830
		C		42.3	48.3	9.44	.68	5.33	73.11	1.42	10.02	7,290	13,130
		D		46.7	53.3		.75	5.89	80.73	1.57	11.06	8,050	14,490
19844	1.3	A	3.8	44.7	44.4	7.09	.61	5.88	71.86	1.39	13.17	7,195	12,950
		B	2.6	45.2	45.0	7.18	.62	5.81	72.78	1.41	12.20	7,290	13,120
		C		46.4	46.2	7.37	.63	5.68	74.71	1.45	10.16	7,480	13,470
		D		50.1	49.9		.68	6.13	80.66	1.57	10.96	8,075	14,540
19846	2.2	A	5.0	41.8	48.4	4.77	.47	5.76	73.10	1.38	14.52	7,255	13,060
		B	2.8	42.8	49.5	4.88	.48	5.63	74.75	1.41	12.85	7,420	13,360
		C		44.0	51.0	5.02	.49	5.48	76.93	1.45	10.63	7,635	13,750
		D		46.3	53.7		.52	5.77	81.00	1.53	11.18	8,040	14,470
19847	1.9	A	4.6	42.3	46.9	6.16	.49	5.72	71.80	1.37	14.46	7,150	12,870
		B	2.8	43.1	47.8	6.28	.50	5.62	73.17	1.40	13.03	7,285	13,120
		C		44.3	49.2	6.46	.51	5.46	75.24	1.44	10.89	7,495	13,490
		D		47.4	52.6		.55	5.84	80.44	1.54	11.63	8,010	14,420
19880	1.0	A	3.3	42.5	48.0	6.19	.40	5.60	73.22	1.35	13.24	7,260	13,060
		B	2.3	43.0	48.5	6.25	.40	5.54	73.99	1.36	12.46	7,335	13,200
		C		44.0	49.6	6.40	.41	5.41	75.72	1.40	10.66	7,505	13,510
		D		47.0	53.0		.44	5.78	80.90	1.50	11.38	8,020	14,430
19879	.9	A	3.0	43.5	46.9	6.57	.47	5.67	73.25	1.41	12.63	7,290	13,120
		B	2.1	43.9	47.4	6.63	.47	5.62	73.93	1.42	11.93	7,360	13,240
		C		44.8	48.4	6.78	.48	5.50	75.56	1.45	10.23	7,520	13,540
		D		48.1	51.9		.51	5.90	81.05	1.56	10.98	8,065	14,520
19881	1.3	A	3.6	45.6	45.4	5.38	.58	6.06	74.33	1.42	12.23	7,410	13,340
		B	2.3	46.2	46.0	5.45	.59	6.00	75.28	1.44	11.24	7,505	13,510
		C		47.3	47.1	5.58	.60	5.87	77.07	1.47	9.41	7,685	13,840
		D		50.1	49.9		.64	6.22	81.62	1.56	9.96	8,140	14,650
19837	2.2	A	4.6	43.3	44.6	7.5	.76					7,065	12,710
		B	2.5	44.2	45.7	7.6	.78					7,220	12,990
		C		45.4	46.8	7.8	.80					7,400	13,320
		D		49.2	50.8		.87					8,035	14,460
19838	1.8	A	4.1	41.3	45.9	8.7	.69					6,990	12,580
		A	2.3	42.1	46.7	8.9	.70					7,120	12,810
		C		43.1	47.8	9.1	.72					7,285	13,110
		D		47.4	52.6		.79					8,015	14,430
19986	2.4	A	4.4	42.9	44.3	8.43	.55	5.78	70.43	1.42	13.39	7,050	12,690
		B	2.1	43.9	45.4	8.63	.56	5.65	72.13	1.45	11.58	7,220	13,000
		C		44.9	46.3	8.82	.58	5.54	73.70	1.49	9.87	7,380	13,280
		D		49.2	50.8		.64	6.08	80.83	1.63	10.82	8,090	14,560

UTAH—Continued.

CARBON COUNTY—Continued.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19987	3.9	A	6.0	42.9	46.2	4.93	0.85	6.03	71.80	1.52	14.87	7,190	12,940
		B	2.2	44.7	48.0	5.13	.88	5.82	74.72	1.58	11.87	7,485	13,470
		C	....	45.7	49.1	5.25	.90	5.70	76.39	1.62	10.14	7,650	13,770
		D	....	48.2	51.8	....	.95	6.02	80.62	1.71	10.70	8,075	14,540
19990	2.8	A	4.9	42.2	44.7	8.15	.39	5.71	70.19	1.36	14.20	6,960	12,530
		B	2.2	43.4	46.0	8.38	.40	5.55	72.17	1.40	12.10	7,160	12,890
		C	....	44.4	47.0	8.57	.41	5.44	73.80	1.43	10.35	7,320	13,180
		D	....	48.5	51.5	....	.45	5.95	80.72	1.56	11.32	8,005	14,410
19988	1.6	A	3.8	45.7	44.5	6.00	.36	5.88	73.12	1.35	13.29	7,260	13,070
		B	2.2	46.5	45.2	6.10	.37	5.79	74.33	1.37	12.04	7,380	13,290
		C	....	47.6	46.2	6.24	.37	5.67	75.99	1.40	10.33	7,545	13,580
		D	....	50.7	49.3	....	.39	6.05	81.05	1.49	11.02	8,050	14,490
19989	2.8	A	4.9	42.8	46.2	6.07	.41	5.80	71.80	1.37	14.55	7,140	12,850
		B	2.1	44.1	47.5	6.25	.42	5.65	73.89	1.41	12.38	7,345	13,220
		C	....	45.1	48.5	6.38	.43	5.53	75.50	1.44	10.72	7,505	13,510
		D	....	48.1	51.9	....	.46	5.91	80.64	1.54	11.45	8,015	14,430

MORGAN COUNTY.

19799	8.7	A	18.1	[a]27.4	35.3	19.23	0.63	5.28	47.47	0.81	26.58	4,540	8,180
		B	10.3	30.0	38.7	21.05	.69	4.73	51.97	.89	20.67	4,970	8,950
		C	....	33.4	43.1	23.47	.77	3.99	57.93	.99	12.85	5,545	9,980
		D	....	43.7	56.3	....	1.01	5.21	75.70	1.29	16.79	7,245	13,040
19800	6.4	A	17.5	[a]27.8	36.9	17.8	.46	....	....	....	....	4,755	8,560
		B	11.9	29.7	39.4	19.0	.49	....	....	....	....	5,085	9,150
		C	....	33.7	44.7	21.6	.56	....	....	....	....	5,770	10,390
		D	....	43.0	57.0	....	.71	....	....	....	....	7,360	13,250

SUMMIT COUNTY.

20894	0.2	A	2.3	38.5	48.9	10.31	5.16	4.98	69.10	0.99	9.46	6,970	12,550
		B	2.1	38.5	49.1	10.33	5.17	4.97	69.24	.99	9.30	6,985	12,570
		C	....	39.4	50.1	10.55	5.28	4.83	70.72	1.01	7.61	7,135	12,840
		D	....	44.0	56.0	....	5.90	5.40	79.06	1.13	8.51	7,975	14,360
20895	.4	A	8.4	[a]32.1	45.0	14.54	.52	3.99	55.67	.96	24.32	4,930	8,870
		B	8.0	32.2	45.2	14.60	.52	3.96	55.90	.96	24.06	4,950	8,910
		C	....	35.0	49.1	15.86	.57	3.34	60.74	1.05	18.44	5,380	9,680
		D	....	41.6	58.4	....	.68	3.97	72.19	1.25	21.91	6,390	11,510

VIRGINIA.

BUCHANAN COUNTY.

19833	3.2	A	4.1	31.7	61.2	2.98	1.07	5.36	80.91	1.51	8.17	8,035	14,470
		B	.9	32.7	63.3	3.08	1.11	5.17	83.58	1.56	5.50	8,300	14,940
		C	....	33.1	63.8	3.11	1.12	5.12	84.33	1.57	4.75	8,375	15,080
		D	....	34.1	65.9	....	1.16	5.28	87.04	1.62	4.90	8,645	15,560
19834	2.7	A	3.5	31.9	60.9	3.73	1.48	5.32	80.89	1.53	7.05	7,995	14,390
		B	.8	32.8	62.6	3.83	1.52	5.16	83.14	1.57	4.78	8,215	14,790
		C	....	33.1	63.0	3.87	1.53	5.11	83.84	1.59	4.06	8,285	14,920
		D	....	34.4	65.6	....	1.59	5.32	87.22	1.65	4.22	8,620	15,520
19735	2.0	A	3.4	28.2	61.4	6.98	.67	5.09	78.30	1.53	7.43	7,670	13,810
		B	1.4	28.8	62.7	7.12	.68	4.97	79.90	1.56	5.77	7,830	14,090
		C	....	29.2	63.6	7.23	.69	4.88	81.06	1.58	4,56	7,940	14,290
		D	....	31.4	68.6	....	.74	5.26	87.37	1.70	4.93	8,560	15,410
19924	1.7	A	2.4	19.5	64.7	13.4	.71	....	....	....	....	7,310	13,160
		B	.6	19.9	65.8	13.7	.72	....	....	....	....	7,440	13,390
		C	....	20.1	66.2	13.7	.73	....	....	....	....	7,490	13,480
		D	....	23.2	76.8	....	.85	....	....	....	....	8,680	15,630

[a] Volatile matter determined by the modified official method.

VIRGINIA—Continued.

MONTGOMERY COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19357	1.9	A	2.5	12.4	67.5	17.60	0.51	3.63	72.83	0.85	4.58	6,865	12,360
		B	.7	12.6	68.8	17.93	.52	3.48	74.21	.87	2.99	6,995	12,600
		C	....	12.7	69.2	18.06	.52	3.44	74.72	.87	2.39	7,045	12,680
		D	....	15.5	84.5	....	.63	4.20	91.19	1.06	2.92	8,600	15,480
19358	1.1	A	1.9	12.3	66.8	18.97	.67	3.54	72.33	.85	3.64	6,755	12,160
		B	.8	12.5	67.5	19.18	.68	3.46	73.13	.86	2.69	6,830	12,290
		C	....	12.6	68.1	19.33	.68	3.39	73.72	.87	2.01	6,885	12,390
		D	....	15.6	84.4	....	.84	4.20	91.38	1.08	2.50	8,535	15,360
22629	.4	A	1.6	12.3	68.1	18.0	.47	....	....	....	....	6,855	12,340
		B	1.2	12.4	68.4	18.0	.47	....	....	....	....	6,885	12,400
		C	....	12.5	69.2	18.3	.48	....	....	....	....	6,970	12,540
		D	....	15.3	84.7	....	.59	....	....	....	....	8,525	15,340
22630	.6	A	1.9	13.5	69.8	14.8	.63	....	....	....	....	7,060	12,710
		B	1.4	13.6	70.2	14.8	.63	....	....	....	....	7,100	12,780
		C	....	13.8	71.1	15.1	.64	....	....	....	....	7,200	12,960
		D	....	16.3	83.7	....	.75	....	....	....	....	8,475	15,260
22631	.8	A	1.8	11.8	53.5	32.9	.33	....	....	....	....	5,430	9,780
		B	1.1	11.9	53.9	33.1	.33	....	....	....	....	5,470	9,850
		C	....	12.0	54.5	33.5	.34	....	....	....	....	5,530	9,960
		D	....	18.1	81.9	....	.51	....	....	....	....	8,315	14,970
19359	2.2	A	3.2	11.4	43.8	41.59	.33	2.89	47.98	.78	6.43	4,455	8,020
		B	1.0	11.7	44.8	42.53	.34	2.70	49.06	.80	4.57	4,560	8,200
		C	....	11.8	45.2	42.98	.34	2.61	49.59	.81	3.67	4,605	8,290
		D	....	20.6	79.4	....	.60	4.58	86.97	1.42	6.43	8,080	14,540
19360	3.9	A	4.7	11.5	65.4	18.44	.56	3.66	70.19	.87	6.28	6,570	11,820
		B	.8	12.0	68.0	19.18	.58	3.36	73.01	.90	2.97	6,835	12,300
		C	....	12.0	68.6	19.35	.59	3.29	73.64	.91	2.22	6,890	12,410
		D	....	14.9	85.1	....	.73	4.08	91.31	1.13	2.75	8,545	15.380
19403	.9	A	1.7	9.4	66.6	22.32	.71	3.19	69.24	.81	3.73	6,430	11,570
		B	.7	9.5	67.3	22.53	.72	3.12	69.89	.82	2.92	6,490	11,680
		C	....	9.5	67.8	22.70	.72	3.05	70.42	.82	2.29	6,535	11,770
		D	....	12.3	87.7	....	.93	3.95	91.10	1.06	2.96	8,455	15,220
PULASKI COUNTY.													
19431F	1.4	A	2.4	11.6	63.3	22.73	0.67	3.37	67.26	0.75	5.22	6,285	11,310
		B	.9	11.8	64.2	23.06	.68	3.26	68.24	.76	4.00	6,375	11.470
		C	....	11.9	64.8	23.28	.69	3.19	68.89	.77	3.18	6,435	11,590
		D	....	15.5	84.5	....	.90	4.16	89.79	1.00	4.15	8,390	15,100
20722	1.9	A	2.5	10.8	63.1	23.6	.41	....	....	....	....	6,250	11,250
		B	.6	11.0	64.3	24.1	.42	....	....	....	....	6,365	11,460
		C	....	11.1	64.7	24.2	.42	....	....	....	....	6,405	11,530
		D	....	14.6	85.4	....	.55	....	....	....	....	8,455	15,220
RUSSELL COUNTY.													
19484	0.8	A	2.1	32.4	58.7	6.8	1.01	....	....	....	....	....	....
		B	1.3	32.6	59.2	6.9	1.02	....	....	....	....	....	....
		C	....	33.1	60.0	6.9	1.03	....	....	....	....	....	....
		D	....	35.5	64.5	....	1.11	....	....	....	....	....	....
19528	1.8	A	3.2	33.1	57.7	6.0	.96	....	....	....	....	....	....
		B	1.4	33.7	58.8	6.1	.98	....	....	....	....	....	....
		C	....	34.2	59.6	6.2	.99	....	....	....	....	....	....
		D	....	36.4	63.6	....	1.06	....	....	....	....	....	....
22345	3.5	A	4.7	30.8	59.4	5.14	.96	5.43	78.33	1.40	8.74	7,760	13,960
		B	1.2	31.9	61.6	5.33	1.00	5.22	81.18	1.45	5.82	8,040	14,470
		C	....	32.3	62.3	5.39	1.01	5.15	82.17	1.47	4.81	8,140	14,650
		D	....	34.1	65.9	....	1.07	5.44	86.85	1.55	5.09	8,600	15,480
22346	1.1	A	2.5	34.2	50.7	12.6	.94	....	....	....	....	7,140	12,850
		B	1.4	34.5	51.3	12.8	.95	....	....	....	....	7,215	12,990
		C	....	35.1	52.0	12.9	.96	....	....	....	....	7,320	13,170
		D	....	40.3	59.7	....	1.10	....	....	....	....	8,410	15,140

VIRGINIA—Continued.

WISE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
22277	1.4	A	3.0	35.9	55.5	5.6	0.78	......	......	......	......	7,760	13,970
		B	1.6	36.4	56.3	5.7	.79	......	......	......	......	7,875	14,170
		C	......	37.0	57.2	5.8	.80	......	......	......	......	8,000	14,400
		D	......	39.3	60.7	......	.85	......	......	......	......	8,490	15,280
22278	1.3	A	2.9	36.1	56.2	4.8	.94	......	......	......	......	7,810	14,060
		B	1.6	36.6	56.9	4.9	.95	......	......	......	......	7,915	14,250
		C	......	37.2	57.9	4.9	.97	......	......	......	......	8,045	14,480
		D	......	39.2	60.8	......	1.02	......	......	......	......	8,460	15,230
22279	1.1	A	2.7	36.3	54.5	6.5	1.37	......	......	......	......	7,690	13,850
		B	1.6	36.8	55.1	6.5	1.39	......	......	......	......	7,780	14,000
		C	......	37.3	56.0	6.7	1.41	......	......	......	......	7,905	14,230
		D	......	40.0	60.0	......	1.51	......	......	......	......	8,470	15,250
22280	1.3	A	2.9	36.1	55.4	5.61	1.05	5.49	78.17	1.67	8.01	7,755	13,960
		B	1.6	36.6	56.1	5.68	1.06	5.42	79.19	1.69	6.96	7,855	14,140
		C	......	37.2	57.0	5.77	1.08	5.32	80.46	1.72	5.65	7,980	14,370
		D	......	39.5	60.5	......	1.15	5.65	85.38	1.83	5.99	8,470	15,240

WYTHE COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
20721	5.2	A	6.1	11.1	49.7	33.1	0.32	......	......	......	......	4,975	8,950
		B	1.0	11.8	52.4	34.8	.34	......	......	......	......	5,245	9,440
		C	......	11.9	52.9	35.2	.34	......	......	......	......	5,300	9,840
		D	......	18.3	81.7	......	.52	......	......	......	......	8,175	14,720

WASHINGTON.

WHATCOM COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
19722	2.6	A	4.4	7.4	76.0	12.23	0.96	2.97	77.75	0.98	5.11	6,995	12,590
		B	1.8	7.7	78.0	12.55	.99	2.76	79.79	1.01	2.90	7,180	12,920
		C	......	7.8	79.4	12.79	1.00	2.60	81.30	1.02	1.29	7,315	13,170
		D	......	8.9	91.1	......	1.15	2.98	93.23	1.17	1.47	8,390	15,100
19723	3.2	A	5.5	6.9	77.7	9.9	1.02	......	......	......	......	7,115	12,810
		B	2.4	7.1	80.3	10.2	1.05	......	......	......	......	7,345	13,230
		C	......	7.3	82.2	10.5	1.08	......	......	......	......	7,530	13,550
		D	......	8.1	91.9	......	1.21	......	......	......	......	8,415	15,150
19724	4.7	A	5.8	8.1	77.1	9.0	.91	......	......	......	......	7,205	12,970
		B	1.2	8.6	80.8	9.4	.96	......	......	......	......	7,560	13,610
		C	......	8.6	81.8	9.6	.97	......	......	......	......	7,650	13,770
		D	......	9.6	90.4	......	1.07	......	......	......	......	8,455	15,220
19725	3.6	A	4.3	9.0	77.2	9.5	1.06	......	......	......	......	7,415	13,350
		B	.7	9.3	80.1	9.9	1.10	......	......	......	......	7,695	13,850
		C	......	9.4	80.7	9.9	1.11	......	......	......	......	7,755	15,960
		D	......	10.4	89.6	......	1.23	......	......	......	......	8,610	15,500
19726	7.4	A	10.7	13.1	68.8	7.4	.94	......	......	......	......	6,610	11,900
		B	3.6	14.1	74.3	8.0	1.02	......	......	......	......	7,140	12,850
		C	......	14.6	77.0	8.4	1.05	......	......	......	......	7,405	13,330
		D	......	16.0	84.0	......	1.15	......	......	......	......	8,080	14,540

WEST VIRGINIA.

CLAY COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21816	1.0	A	2.5	35.6	54.9	7.0	0.86	......	......	......	......	7,595	13,670
		B	1.5	36.0	55.5	7.0	.87	......	......	......	......	7,670	13,810
		C	......	36.6	56.3	7.1	.88	......	......	......	......	7,785	14,020
		D	......	39.4	60.6	......	.95	......	......	......	......	8,385	15,100
21817	1.5	A	2.9	34.8	54.1	8.2	1.09	......	......	......	......	7,470	13,450
		B	1.4	35.4	54.9	8.3	1.11	......	......	......	......	7,580	13,650
		C	......	35.9	55.7	8.4	1.12	......	......	......	......	7,690	13,840
		D	......	39.2	60.8	......	1.22	......	......	......	......	8,400	15,120
21818	1.2	A	2.6	35.5	54.3	7.56	.98	5.33	75.89	1.48	8.76	7,530	13,560
		B	1.4	35.9	55.0	7.65	.99	5.25	76.84	1.50	7.77	7,625	13,730
		C	......	36.4	55.8	7.76	1.01	5.18	77.95	1.52	6.58	7,735	13,930
		D	......	39.5	60.5	......	1.10	5.61	84.51	1.65	7.13	8,385	15,100
21892	1.5	A	3.1	36.5	54.4	6.0	1.49	......	......	......	......	7,670	13,800
		B	1.7	37.0	55.2	6.1	1.51	......	......	......	......	7,785	14,010
		C	......	37.6	56.2	6.2	1.54	......	......	......	......	7,915	14,250
		D	......	40.1	59.9	......	1.64	......	......	......	......	8,440	15,190

NICHOLAS COUNTY.

Laboratory No.	Air-drying loss.	Form of analysis.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
21819	4.4	A	5.7	32.8	56.6	4.86	1.42	5.77	76.08	1.60	10.27	7,565	13,620
		B	1.3	34.4	59.2	5.09	1.49	5.53	79.62	1.67	6.60	7,915	14,250
		C	......	34.8	60.0	5.15	1.51	5.44	80.70	1.70	5.50	8,025	14,440
		D	......	36.7	63.3	......	1.59	5.74	85.08	1.79	5.80	8,460	15,230
21820	3.2	A	4.5	33.7	56.7	5.11	.93	5.87	76.18	1.62	10.29	7,675	13,820
		B	1.3	34.8	58.6	5.28	.96	5.69	78.73	1.67	7.67	7,930	14,280
		C	......	35.3	59.4	5.35	.97	5.63	79.81	1.70	6.54	8,040	14,470
		D	......	37.3	62.7	......	1.02	5.95	84.32	1.80	6.91	8,495	15,290

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